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ORIGINAL ARTICLES.

The Formation of Lake Geneva.

By E. Joukowsky, D.Sc., Mining Engineer (Paris).

On studying a topographical map of Lake Geneva, two characteristic features strike one at once. There is, first of all, the division of the basin into two parts of different orientation—the " Grand Lac " set almost E.W., and the " Petit Lac " deviated by about 60° towards the S.S.W. The inhabitants of the region have always distinguished between the " Grand Lac ", also called " Haut Lac ", and the " Petit Lac ". The former has a depth of 300 metres and consists of a single basin, the floor of which is remarkably flat; whilst the second, separated from the other by a submerged ridge 66·3 metres below the surface, begins by a first fosse 76·2 metres deep, followed by three others 70·1, 70·4, and 50·1 metres deep respectively. If Lake Geneva is considered as having a single origin, and if the theory of glacial overdeepening is adopted, it is very difficult to explain the ridge separating the two basins. On the other hand, the " Haut Lac ", taken alone, presents nothing abnormal, compared with other basins in whose formation glaciers have taken a large part.

The second characteristic to be noted is the curious path followed by the outflowing stream: apart from meanders, the Rhone below the lake is almost perpendicular to the axis of the " Petit Lac "; in fact, it seems to be an element of the Arve course, which formerly flowed through the Monnetier Pass (at the present time deserted and hanging at a height of 700 metres) towards the defile of Bellegarde. We are naturally speaking of the course of the Arve as it was during the glacial period, before it outflanked the Salève ridge north of Monnetier. It is true that the different cycles of erosion which have succeeded each other since the making of the pre-Glacial hydrographical net, may have produced important displacements of the streams, but the general drainage line between Monnetier and Bellegarde must always have been a curve agreeing approximately with the actual course of the Arve and the Rhone.

If these two facts are considered together: on the one hand the evident discontinuity between the "Grand" and the "Petit Lac", and on the other the "Arvian" character of the outflow of the lake between Geneva and Bellegarde the following question presents itself: was there communication between the two Geneva basins in pre-Glacial times?

This question has presented itself continually to me in the course of my studies regarding the basin of the "Petit Lac", studies facilitated by a considerable number of borings made in the last few years (5)[1]. An attempt to co-ordinate the numerous observations of different glacialists on the lakes of Geneva and Neuchâtel, and the basins of the Arve and the Rhone below Geneva, seems to indicate that the answer is in the negative, and that communication between the "Grand" and "Petit Lac" is of comparatively late date. For instance, several authors have noted a number of proofs about a "Grand Lac" of a water-level above 530 metres (the present level of Lake Geneva is 373·60 metres); and Brückner (3), who

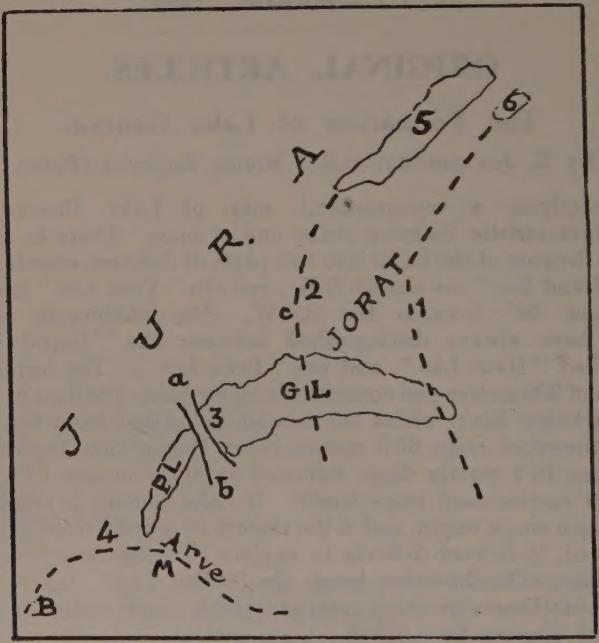

FIG. 1.—Lake Geneva, etc.

1. Rhone. 2. Dranse. 3. Gimel-Boisy ridge. 4. Arve. 5. Lake Neuchâtel. 6. Lake Morat. *a.* Gimel. *b.* Boisy. *c.* La Sarraz, Mormont. G.L. Grand Lac. P.L. Petit Lac. M. Monnetier Pass (deserted and hanging) through the Salève ridge. B. Bellegarde defile.

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[1] Figures in parentheses refer to Bibliography at end of paper.

was the first to give a synthesis of the formation of Lake Geneva, has already laid stress on the fact that no vestiges of such a level exist in the basin of the " Petit Lac ". This fact further emphasizes the differences we have pointed out between the " Grand " and the " Petit Lac ".

It is easy to discover a link between the data observed in the different parts of the basin by referring to the hypothesis put forward by Mr. Lugeon (1) in 1897 as to the probable topography of the pre-Glacial Rhone-Rhine hydrographical net, and by analysing all its consequences. The hypothesis is this : the Valais Rhone had its outflow through the valley of Broye towards Lake Morat. The Chablais Dranse flowed towards Lake Neuchâtel. These two streams were thus tributaries of the Rhine. The Arve alone flowed—at a level of about 300 metres higher than its actual one—between the Monnetier Pass and the Bellegarde defile, towards the Mediterranean.

Consequently the two basins of the Arve and the Rhone must have been separated by a ridge formed entirely of Aquitanian Molasse (marly sandstone), easily wasted by water and frost. On the other hand, the crest separating the lakes of Neuchâtel and Geneva is a fragment of a Lower Cretaceous limestone plateau, called Mormont, covered by Molasse and glacial deposits, forming a transversal chain between the first Jura chain and the Jorat hills. Its lowest part, 570 metres high, in the neighbourhood of La Sarraz, is of limestone. The Mormont contains three old canyons filled up by glacial deposits, whose age is not yet precisely known (8). Whilst water easily wasted the " molasse " of the " Petit Lac " territory, the outflow of the lake towards the Rhine met the resisting crest of La Sarraz. On the basis of this interpretation of the Rhone-Rhine waters, let us examine the following hypothesis :—

The basin of a pre-Glacial Arve tributary occupied the actual site of the " Petit Lac ". It was separated from the Rhone-Rhine basin by a Molasse divide of which the Gimel and Boisy hills are the remains. We shall call this hypothetical tributary the " Petit Lac stream ". This stream, wasting the soft Molasse, lowered its bed quicker than could the outflow of the " Grand Lac " through the La Sarraz ridge, and ended by capturing the waters of the " Haut Lac "—to the benefit of the Mediterranean basin. Here two possibilities have to be considered : Firstly, capture before the first glacial extension ; secondly, capture during one of the interglacial periods.

First case.—The beginning of the glacial reign would have produced the widening of a breach through the Molasse divide and the lowering of the Gimel-Boisy ridge to its actual height. In this case all the glaciations would have sent Valais rocks into the " Petit Lac stream ".

Second case.—This second hypothesis, which appears to me the more reasonable in the light of available information, admits the capture of the "Haut Lac" during the inter-glacial Mindel-Riss period. It finds support in numerous bores put down during the last few years in the neighbourhood of Geneva, where the existence of deep valleys, carved in the Molasse, 30 to 40 metres deeper than the actual valleys, has been ascertained. The filling of these valleys shows without any exception the following succession, resting upon Aquitanian Molasse (6) (7) :—

(1) Rissian "moraine" (at the bottom).
(2) Riss-Wurmian interglacial and fluvioglacial.
(3) Wurmian moraine, overlying the whole "Petit Lac" basin.

All these layers contain abundant pebbles of the Alpine rocks from the Valais region. It looks as if Rissian glaciers from the Valais had found it easier than their Mindelian predecessors to extend into the "Petit" basin owing to the lowering in Mindel-Rissian times of a ridge that had formerly limited the confluence of the Valais and Arve glaciers.

Another good reason for regarding the capture as of interglacial date is furnished by the fluvio-glacial vestiges of the 530 metre level for the "Grand Lac" and the absence of any corresponding terrace in connexion with the "Petit Lac".

This manner of conceiving the genesis of Lake Geneva, whatever date-hypothesis is adopted, leads me to define the "Petit Lac" as an "appendice de capture". It entails various consequences, which I now indicate. At a moment, that I tentatively attribute to the Mindel-Riss interglacial, an outflow of the "Grand Lac" was established through the soft Molasse ridge (Gimel-Boisy). On the other hand, somewhere below the capture, an accumulation of material must have occurred. Noting that the deep Molasse-bounded valley mentioned above, under the actual Rhone, is continued below Bellegarde, we must perhaps seek in the region of the Rhone and the Saône confluent the remains of that accumulation. A fact which has preoccupied geographers a great deal—the convexity of the bed of the Rhone between Lyon and Valence (4)—is perhaps partly due to that accumulation.

For the further pursuit of these studies, especially interesting in regard to the evolution of the hydrographical nets during the glacial periods, superficial studies are in most cases insufficient, because, generally speaking, we cannot affirm precisely the age of glacial deposits. A bore in the right place may be more successful than months of surface studies. Unfortunately, it is not the custom to put down bores whose sole aim is to elucidate a theoretical question, without material profit to anybody.

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Silurian Graptolites from Studley Park, Melbourne, Australia.

By O. A. Jones, B.Sc., Research Student, Emmanuel College, Cambridge.

(PLATE V.)

Summary.—Four species of *Monograptus* are described and the age of the strata shown to be that of the zone of *M. nilssoni* of the Lower Ludlow of Great Britain.

Introduction.—The graptolites described below are a part of a collection made by the author in June, 1926. The specimens were all collected from one band about 1 foot wide in the cutting overlooking the river at Studley Park; they are preserved in a soft, grey, fine-grained but well-bedded mudstone; they are present in great numbers, being often so crowded as to obscure their structure. Although complete examples are few, a large number show the structure excellently preserved. Hitherto comparatively few and poorly preserved specimens had been obtained and only one species had been recorded—*M. dubius*. The importance of the present collection lies not only in the finding of unrecorded species but in that it has a very important bearing on the age of the strata.

Previous Work.—The literature on the area is scarce, consisting of notes of excursions held by the Victorian Naturalists' Club, and of a few references to the fauna. Chapman (1)[1] in 1913, recorded the following fossils: cf. *Streptelasma*, *Camarotoechia decemplicata*, *Chonetes melbournensis* and *Loxonema* sp. In 1914 (2), he mentions *Monograptus dubius* as being found in some abundance. For the Pan-Pacific Congress of 1923 (3), a paper on the area was prepared by H. B. Hauser, who gave the fossils recorded by Chapman.

Description of the Species.—All the species described below have mature thecae which are simple, straight, overlapping tubes with approximately parallel walls and even apertural margins; all have biform thecae (i.e. the proximal thecae differ from the distal), and in all the polypary is approximately straight. It is somewhat remarkable that *all* should be identical with species from localities as far away as Great Britain, but I have no doubt that such is the case.

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[1] Figures in parentheses refer to list at end of paper.

Monograptus chimaera (Barrande). (Plate V, Figs. 1 *a–d*.)

1850. *Graptolithus chimaera* Barrande, *Graptolites de Bohême*, p. 52, pl. iv, figs. 34, 35.
1911. *Monograptus chimaera* Elles and Wood, *Mon. Brit. Graptolites*, Palaeont. Soc., p. 398, pl. xxxix, figs. 3 *a–d*.

The polypary is straight distally, but with slight ventral curvature proximally; it increases rapidly in width at first, then gradually to a maximum breadth of about 2 mm. Thecae with spined apertural margin, four times as long as wide and overlapping about half their extent; average inclination 40° to 50°. The thecae in the proximal portion show signs of ogee curvature and retroversion of their apertures.

Horizon in Britain: Salopian; zones of *M. nilssoni* and *M. scanicus*.

Monograptus roemeri (Barrande). (Plate V, Figs. 2 *a–c*.)

1850. *Graptolithus roemeri* Barrande, *Graptolites de Bohême*, p. 41, pl. ii, figs. 9–11.
1911. *Monograptus rœmeri* Elles and Wood, *Mon. British Graptolites*, Palaeont. Soc., p. 397, pl. xxxix, figs. 2 *a–d*.

Polypary with slight ventral curvature proximally and slight dorsal curvature distally, increasing in width rapidly at first, then more gradually to the maximum of about 3 mm. The mature thecae are approximately straight walled, simple tubes increasing in length distally; 5 or 5½ times as long as broad; overlapping fully two-thirds of their length; average inclination 40° to 45°. The two proximal thecae have retroverted apertural extremities. The slight double curvature of the polypary is highly characteristic, as are also the long thecae and rapid increase in width in the proximal portion.

Horizon: Salopian; zones of *M. nilssoni* and *M. scanicus*.

Monograptus colonus (Barrande).

1850. *Graptolithus colonus* Barrande, *Graptolites de Bohême*, p. 42, pl. ii, figs. 2, 3.
1911. *Monograptus colonus* Elles and Wood, *Mon. British Graptolites*, Palaeont. Soc., p. 391, pl. xxxviii, figs. 8 *a–d*.

The polypary is similar to that of *M. chimaera* but has a slightly greater width—2·3 mm. The thecae also are like those of *M. chimaera* except for the absence of spines, greater overlap—⅔ of their length and rather less angle of inclination—35° to 45°.

Horizon: Salopian; *M. nilssoni* zone.

Monograptus varians Wood.

1900. *Monograptus varians* Wood, *Q.J.G.S.*, lvi, p. 457, pl. xiv, figs. 14*a*, 14*b*, 15, 16*a*, 16*b*.
1911. *Monograptus varians* Elles and Wood, *Mon. British Graptolites*, p. 395, pl. xxxix, figs. 6 *a–e*.

	Llandovery or Birkhill.						Tarannon or Gala.				Wenlock.						Lower Ludlow.				
	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
	Zone of *Cephalo. acuminatus*	,, *Meso. modestus* and *Ortho. vesiculosus*	,, *M. cyphus*	,, *M. gregarius* (*a*) subzone of *M. frimbriatus* (*b*) ,, *M. triangulatus* (*c*) ,, *M. argenteus*	Band of *Cephalo. cometa* Zone of *M. convolutus*	,, *M. sedgwicki*	,, *M. turriculatus*	,, *M. crispus*	,, *M. griestoniensis*	,, *M. crenulatus*	,, *Cyrto. murchisoni*	,, *M. riccartonensis*	,, *Cyrto. symmetricus*	,, *Cyrto. linnarssoni*	,, *Cyrto. rigidus*	,, *Cyrto. lundgreni*	,, *M. vulgaris*	,, *M. nilssoni*	,, *M. scanicus*	,, *M. tumescens*	,, *M. leintwardinensis*
Monograptus chimaera .	–	–	–	– – – –	–	–	–	–	–	–	–	–	–	–	–	–	–	+	+*c*		
,, *colonus* .	–	–	–	– – – –	–	–	–	–	–	–	–	–	–	–	–	–	–	+			
,, *concinnus* .	–	–	+	+ + +	+ +	+															
,, *cyphus* .	–	–	+*c*																		
,, *dubius* .	–	–	–	– – – –	–	–	–	–	–	–	+*c*	+	+*c*	+*c*	+*c*	+*c*	+	+*c*	+		
,, *exiguus* .	–	–	–	– – – –	–	–	+	+													
,, *nodifer* .	–	–	–	– – – –	–	–	+	+													
,, *priodon* .	–	–	–	– – – –	–	–	+?	+	+	+	+*c*	+*c*	+	+*r*							
,, *riccartonensis* .	–	–	–	– – – –	–	–	–	–	–	–	+*r*	+*c*									
,, *roemeri* .	–	–	–	– – – –	–	–	–	–	–	–	–	–	–	–	–	–	–	+	+		
,, *turriculatus* .	–	–	–	– – – –	–	–	+*c*	+													
,, *varians* .	–	–	–	– – – –	–	–	–	–	–	–	–	–	–	–	–	–	–	+			

Polypary straight with slight ventral curvature near the proximal end; maximum width about 2 mm.

Typically the three proximal thecae have retroverted margins; the mature thecae are simple tubes with very wide apertural margins, two or three times as long as wide; overlap about one-half; average inclination 30° to 40°. In the mature thecae the great width of the apertural margin often results in a distinct compression of the ventral margin of the theca next above, resulting in a most characteristic appearance.

Horizon: Salopian; zone of *M. nilssoni.*

All but one of the specimens which are at all well preserved, seem referable to these four species; the exception bears resemblance to *Monograptus uncinatus*, but is not definite enough to record.

Age of the Beds.—An examination of the table (p. 103) shows that the four species described above are present in one zone, that of *M. nilssoni*, while one, *M. chimaera*, is common in, and another, *M. roemeri*, occurs in the zone next above—that of *M. scanicus.* This indicates that the strata are the equivalents of the *M. nilssoni* zone of the Lower Ludlow of Great Britain. Of the four species *M. chimaera* is the most common, closely followed by *M. roemeri* and *M. colonus*, while *M. varians* is comparatively rare. This profusion of *M. chimaera* indicates that the beds are near the top of the *M. nilssoni* zone, since this form is more common in the zone next above (*M. scanicus*).

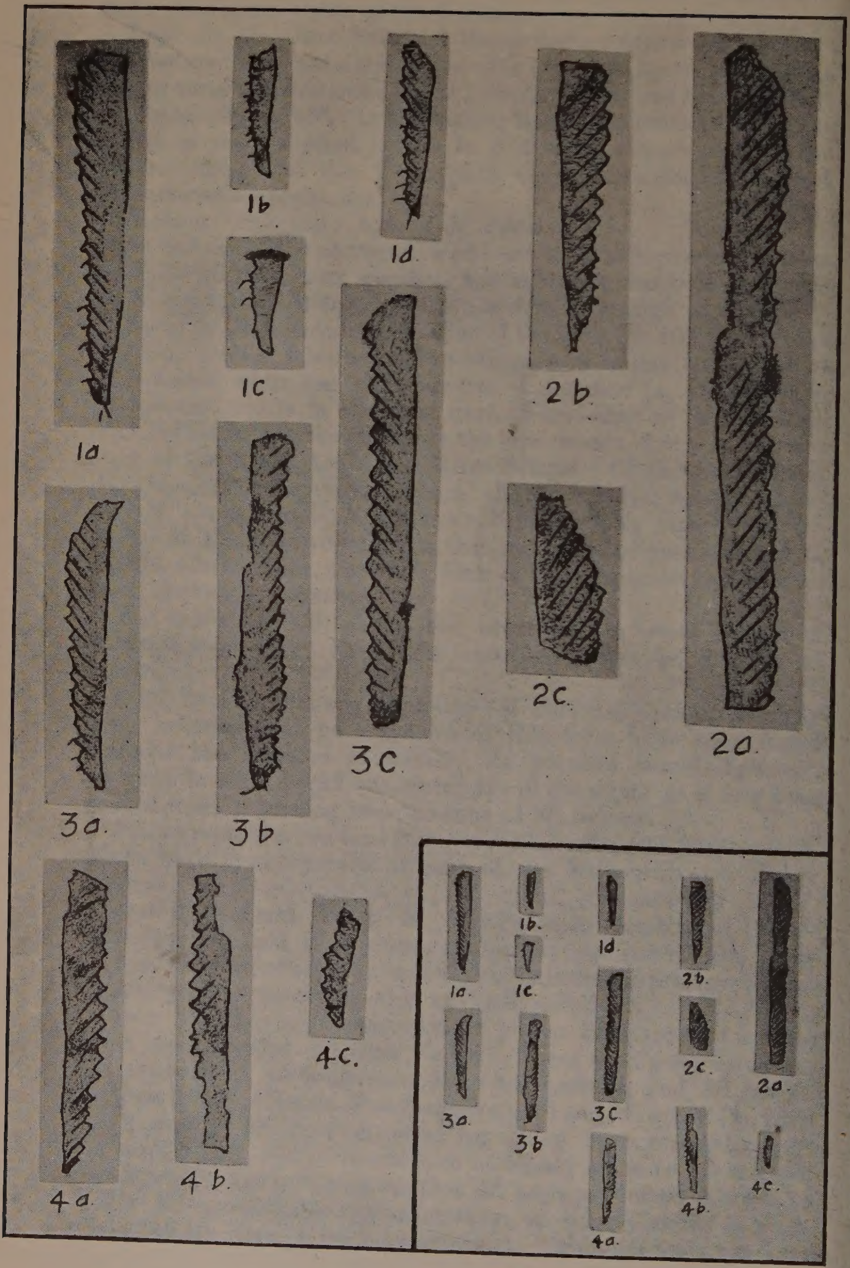
The table (p. 103) shows the occurrence in Great Britain of Monograptidae that have been recorded from the Silurian of Australia.

From Studley Park one graptolite—*M. dubius* (7)—has previously been recorded, but no examples of this form have been found amongst the material examined; its presence would, however, be quite in accord with the stated age of the strata as it is a long ranged form, extending into the zone of *M. nilssoni.*

Other graptolites recorded from the Melbournian (the Studley Park strata have been regarded as part of the Melbournian or Lower Silurian) are *Dendrograptus* sp., *M.* sp. cf. *concinnus*, *M.* sp. cf. *cyphus* from South Yarra, *M. priodon* from Macclesfield (? Melbournian) (1), and *M. turriculatus* (locality not stated) (8). The ranges of these forms (shown in the table) indicate the presence of considerably lower zones than that at Studley Park.

From the Yeringian (regarded as Upper Silurian) five species have been recorded (all from Keilor). These are *Cyrtograptus* sp., *M. priodon*, *M. riccartonensis*, *Retiolites australis*, and *M. aplini.* Hall records and figures *Monograptus* sp. (6) and *M. aplini* (8), from this locality. The figure he gives for *M.* sp. bears resemblance to *M. nodifer*; *M. aplini* he states to be closely allied to *M. exiguus*, but Dr. Elles has informed me that *M. exiguus* is often as small as Hall's *M. aplini* (Hall separated them on the difference in size), and that she regards them as identical. These species show that

PLATE V.



AUSTRALIAN GRAPTOLITES.

To face p. 105.]

the Keilor beds are considerably older than those at Studley Park, and that either they do not belong to the Yeringian or else that the Yeringian is of Lower and not Upper Silurian age; also that among others the zone of *M. turriculatus* or that of *M. crispus* is present at this locality.

From the Tanjilian (the uppermost Silurian) three species, ? *Cyrtographus* sp., *M.* sp. cf. *crenulatus*, and *M. dubius*, have been recorded. These determinations are not of zonal value.

Conclusions.—(1) The age of the Studley Park beds is Lower Ludlow;

(2) The only zone at present known to be represented is that of *M. nilssoni*;

(3) Strata which previously were regarded as younger than those at Studley Park are in reality older;

(4) At Keilor the zone of *M. turriculatus* or that of *M. crispus* is represented and probably also several others.

Since the above was written a further paper has come under the notice of the author. This is a " Report on Graptolites ", by R. A. Keble, in the *Records of the Geological Survey of Victoria*, vol. iv, part iv, p. 479 (1925). The locality is Howe's Creek, parish of Loyola. Mr. Keble records *Monograptus leptotheca* Lap., *M. McCoyi* Lap., *M.* sp. cf. *cutellus* Törnquist, *M.* cf. *proteus* Barrande, *M.* (*monoclimacis*) sp. indet., *M.* spp. nov., *Climacograptus* sp., *Diplograptus* sp., *Retiograptus* sp.; he puts the age as equivalent to the Llandovery of England. This record further supports the author's conclusion that careful collecting will reveal the presence of many zones in the Silurian of Victoria. The author wishes to record his thanks for valuable advice and assistance from Dr. Elles.

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(3) " Pan-Pacific Science Congress, 1923," Leaflet by H. Hauser.
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(6) Geol. Mag., 1899, p. 439.
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(8) *Proc. Roy. Soc. Vict.*, xxvii (N.S.), p. 114, 1914.

EXPLANATION OF PLATE V.

Figs.
1 *a–d.*—*Monograptus chimaera* (× 3·5). *b, c, d* proximal ends.
2 *a–c.*—*M. roemeri* (× 3·5); *b*, proximal end; *c*, distal end showing very long thecae.
3 *a–c.*—*M. colonus* (× 3·5).
4 *a–c.*—*M. varians* (× 3·5); *c*, proximal end.

The figures in bottom right-hand corner are natural size.

Studies in Avonian Brachiopoda: I. The Genera *Brachythyris* and *Martinia*.

By T. Neville George, M.Sc., Fellow of the University of Wales, University College of Swansea.

I. Introduction.

In 1844 M'Coy[1] subdivided the genus *Spirifer* Sowerby into five groups, two of which, *Brachythyris* and *Martinia*, were characterized by "the presence of a hinge-line shorter than the width of the shell". *Brachythyris* included forms "in which . . . the longitudinally-ribbed surface of *Spirifera* is united with the short hinge line of *Martinia*". The latter included "the smooth spirifers". M'Coy's subdivisions, however, have not been much used. More recently Mr. S. S. Buckman[2] has shown that the smooth forms grouped by M'Coy and others in *Martinia* are the catagenetic members of several spiriferid stocks. Buckman considered that *Martinia* and *Brachythyris* were distinct from the other spirifers in their shape and in their lack of dental plates.

Abundant specimens of *Martinia* aff. *glabra* and rarer forms of other species of these two genera have been collected by the writer from the Upper Limestone Shales of Gower.[3] These strata were described by Mr. E. E. L. Dixon and the late Dr. A Vaughan;[4] the fauna received considerable attention from Vaughan, as it marked a higher horizon in the Avonian than had previously been found in the South-West Province. Vaughan's descriptions referred mainly to the external characters of the fossils, and little information was given concerning the internal characters. At several localities in Gower these beds are frequently in the condition of rottenstone, and the writer has obtained beautifully preserved internal casts of many of the fossils, particularly from Port Eynon.

The present paper deals with the characters of shells allied to *Brachythyris* and *Martinia*, and is mainly based on a study of material collected from the Upper Limestone Shales of Gower. A large series of related brachiopods, chiefly from the Carboniferous Limestone of the Midlands and the north of England, in the collection of the late Mr. T. W. Reader, now in the University College of Swansea, has also been studied.

The writer wishes to express his indebtedness to Mr. D. O. Williams, of Merton College, for help in the field, and for many of the specimens collected, and also to Dr. A. E. Trueman, who has proved an invaluable source of advice and encouragement and under whose guidance the work was carried out.

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[1] F. M'Coy, *Syn. of the Carb. Lst. Foss. of Ireland*, 1844, p. 128.

[2] S. S. Buckman, "Brachiopod Homoeomorphy": *Q.J.G.S.*, vol. lxiv, 1908, p. 27.

[3] For a description and a history of the nomenclature of these beds, see "The Geol. of the S. Wales Coalfield", pt. viii, "The Country around Swansea": *Mem. Geol. Surv.*, 1907, p. 21.

[4] E. E. L. Dixon and A. Vaughan, "The Carboniferous Succession in Gower": *Q.J.G.S.*, vol. lxvii, 1911, pp. 491, 504, 549.

II. DESCRIPTION OF GENERA AND SPECIES.

1. BRACHYTHYRIS M'Coy.

This genus was originally defined as containing those ribbed spirifers which possess a hinge-line shorter than the width of the shell. A further character, whose diagnostic value was noted by Buckman, is the small size or absence of dental plates. In no specimens examined by the writer have dental plates been seen. The genus, however, appears to need further subdivision since at least two groups may be distinguished by the character of the mesial fold, viz. :—

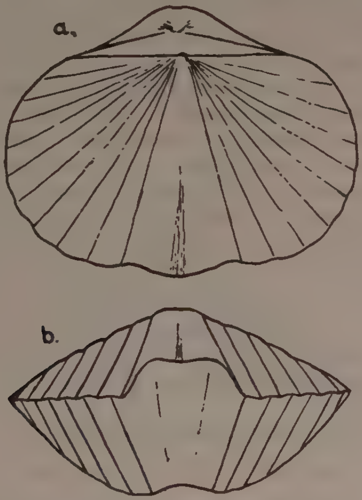

FIG. 1.—*Brachythyris pinguis*, showing the median groove in the mesial fold. Natural size.

(*A*) The mesial fold has a median groove, and the number of ribs on the fold is usually an even number. This fold is well seen in typical forms of *B. pinguis* (Fig. 1).

(*B*) The mesial fold possesses a median rib, and the number of ribs on the fold is always an odd number (usually three). This type of fold is well exemplified in *B. integricosta*.

In *B. ovalis* and certain related forms the mesial fold is usually entire, but in otherwise typical specimens a faint indication of a median groove is sometimes seen near the anterior margin,[1] and it may be suggested that *B. ovalis* is related to Group A.

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[1] See, for example, T. Davidson, "Brit. Foss. Brach.," vol. ii, *Mon. Pal. Soc.*, 1859, pl. ix, fig. 20.

Brachythyris M'Coy. Genotype, *B. ovalis* (Phillips).[1]

Group A: the *B. pinguis* group.

Radially ribbed; hinge-line shorter than the width of the shell; no dental plates; mesial fold divided by a median groove.

Brachythyris ovalis (Phillips).

Usually longer than wide, being almost perfectly elongate-oval in shape; mesial fold entire in the type, but otherwise identical specimens bear traces of a median groove near the anterior margin.

Brachythyris pinguis (Sowerby).[2]

This species differs from the preceding in proportions (it is usually wider than long, and its hinge-line is proportionately longer), and in the fact that the median groove is very prominent, and often extends from near the hinge-line to the anterior margin.

The internal features seem to be variable. A shell from Preston (Reader Coll.) shows a triangular muscle scar slightly depressed into a rather thick test, in the ventral valve. The scar merges anteriorly into the general curve of the shell. Each flank bears feeble angular grooves (presumably vascular markings) which are somewhat uneven and occasionally dichotomose. They extend from near the umbo for about a third of the distance to the anterior margin, when the cast is hidden by shell substance.

On the other hand another specimen has a much thinner shell, and apparently the internal surface is quite smooth.

Brachythyris subrotundata M'Coy.

This form is very similar to, if not identical with, *B. pinguis* in external form.

Brachythyris hemisphericus M'Coy.

This form seems to be a broad variant of the *ovalis* species-group, with the mesial fold just beginning to become grooved. It is peculiar, however, in the possession of a very flat dorsal valve.

Brachythyris linguifera (Phillips).[3]

This differs from all the preceding species in the fact that ribs are absent from the umbonal region, appearing at about half the distance from the hinge-line to the anterior margin. In general outline and plan of mesial fold it is very similar to *B. ovalis*, and possibly represents an earlier stage than *B. ovalis* itself.

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[1] J. Phillips, *Geol. of Yorks.*, pt. ii, 1836, p. 219, and pl. x, fig. 5.
[2] J. Sowerby, *Min. Conch.*, vol. iii, 1820, p. 125, and pl. cclxxi.
[3] Op. cit., p. 219, and pl. x, fig. 4.

Brachythyris sulcata sp. nov. (Fig. 2.)

Hinge-line short, straight, about a third the width of the shell; beak small, umbones disjunct; valves in the intertext stage; margin sulciplicate. Dimensions: length, 39 mm.; breadth, 46 mm.; depth, 23 mm.

In the ventral valve the sinus is broad and shallow, and extends from the umbonal region to the anterior margin, becoming increasingly prominent. Surface ornamented only by very fine growth-lines.

In the dorsal valve there is a mesial fold corresponding to the sinus of the ventral valve, more or less sharply differentiated from the flanks. Near the anterior border a slight median furrow is developed in the fold, and the margin is slightly sulciplicate.

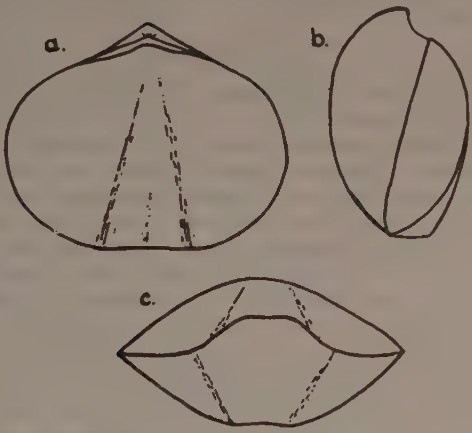

Fig. 2.—*Brachythyris sulcata* sp. nov. Holotype. ? D_2 Zone, Preston. Natural size.

Holotype: A specimen from the Carboniferous Limestone (probably D_2 Zone) of Preston, Brit. Mus. (N.H.) Coll., No. B 48910 ex Reader Coll.

This species combines the smooth form of the typical *Martinia glabra* with the grooved mesial fold of *Brachythyris*. In the holotype the median groove is only developed at a considerable distance from the umbo, but in other specimens (e.g. some figured by Davidson as *Martinia glabra*[1]) the groove extends practically throughout the length of the shell.

Group B: the *B. integricosta* group.

Radially ribbed; hinge-line shorter than width of shell; no dental plates; mesial fold with a median rib.

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[1] Op. cit., pl. xi, figs. 1 and 2.

Brachythyris integricosta (Phillips).[1]

This species has the same general shape and type of ribbing as *B. ovalis*. It differs in the character of the mesial fold, which is triplicate and possesses no median groove. Dental plates are absent in the specimens examined by the writer.

Brachythyris rotundata (Martin)[2] non (Sowerby) and *B. paucicostata* (M'Coy)[3] are similar to *B. integricosta* in the possession of a triplicate mesial fold but differ in shell-shape and in the number of ribs.

[Buckman has suggested[4] that probably *Spirifer bisulcatus* Sowerby is a brachythyrid, but the facts that *S. bisulcatus* possesses a hinge-line equal to the width of the shell, a multiplicate mesial fold, and well-developed dental plates (though not to be compared with those of, e.g., *S. striatus*) remove that species from the brachythyrids.]

2. MARTINIA M'Coy.

Apparently, although Buckman has pointed out the danger of grouping together smooth forms with similar outward appearances, *Martinia* still continues to retain the catagenetic end-forms of several lineages. Buckman himself pointed out the difficulty of distinguishing smooth forms of *Brachythyris* from smooth *Martinias*. A study of the various *Martinias* leads to the view that the genus as at present defined contains at least two groups, but as the ribbed forms of these are at present unknown, and as the separation of many of the smooth forms would be extremely difficult, if not impossible, it is proposed to retain these groups under the generic name of *Martinia*.

Martinia M'Coy. Genolectotype, *M. glabra* (Martin),[5] Buckman.[6] Smooth or only partially ribbed (either on one valve only or near the umbo) in known forms; hinge-line shorter than width of the shell; mesial fold entire; no dental plates.

Martinia glabra (Martin).

This species, as figured by Martin, is narrower than M'Coy's figured type of *Martinia*, with a proportionately broader mesial fold showing no trace of a median groove or of subdivision into ribs. It is quite distinct from forms having a prominent median groove which Buckman apparently considered to be typical members of the species,[7] but which are referred to in this paper as *Brachythyris sulcata*. Some of the specimens from the Upper Limestone

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[1] Op. cit., p. 219.
[2] W. Martin, *Pet. Derb.*, 1809, tab. xlviii, figs. 11 and 12.
[3] F. M'Coy, *Brit. Pal. Foss.*, 1855, p. 420.
[4] Op. cit., p. 30.
[5] Op. cit., pl. xlviii, fig. 10.
[6] Op. cit., p. 30.
[7] Ibid., p. 31, quoting Davidson, op. cit., pl. xi, fig. 2.

Shales of Gower are very similar in outward form to M'Coy's figure already mentioned, but there is a great and apparently continuous variation from thin transverse shells (approaching M'Coy's figure) to more globose equidimensional forms. The latter are usually of smaller size than the former, and it is probable that they frequently represent an earlier stage in growth. This large amount of variation rather discounts Buckman's suggestion that the smooth forms of *Brachythyris* may be distinguished from the smooth *Martinias* by being broader and flatter. Independent of this variation in size and proportions, there is a large amount of variation in the depth and breadth of the sulcus of the ventral valve; in some specimens it is very feeble, whilst in others it is deep and relatively narrow. In some forms referred to *Martinia* aff. *glabra* from the D_2 and D_{2-3} Zones of the North Crop of the South Wales Coalfield, the sulcus is practically absent; in others it is deep and more or less angular. The mesial fold in the dorsal valve rarely corresponds in proportions with the ventral sulcus, and usually is little more than a broad low mesial swelling, scarcely differentiated from the flanks.

A form very nearly allied to, if not identical with, the true *M. glabra* is plentiful in the Upper Limestone Shales (D_{2-3} Zone) of South Wales. As these beds are frequently in the condition of rottenstone (being worked economically as such on the North Crop of the Coalfield) it is possible to obtain casts of these specimens which show the internal features in great detail. In the case of shells preserved in unweathered rock (such as is the usual condition in the "Black Lias" quarry at Oystermouth, where the beds are worked for lime and roadstone) it has been found possible in many instances where the rock is particularly impure and fine-grained to dissolve away the shell-substance with dilute hydrochloric acid, the matrix remaining more or less hard throughout the process. Similar artificial casts have been obtained by the method of burning outlined by Mr. Buckman,[1] but this has been found less satisfactory than the solution method, as a thin layer of shell generally remains, obscuring the detail.

The description which follows is that of the appearance as seen on the casts, simply as a matter of convenience in presentation.

The chief internal features, consisting of muscular impressions, genital markings, and vascular markings, exhibited by the casts, present an extraordinary amount of variation, which, like the variations in shell-shape, is apparently quite independent for each character.

Muscle Impressions.—In the ventral valve the shape of the scars is more or less triangular or rhomboidal, and the area covered by them occupies the greater portion or all of the posterior region. The area is of varying proportions. In the majority of specimens it is much less than half the length of the shell—usually about

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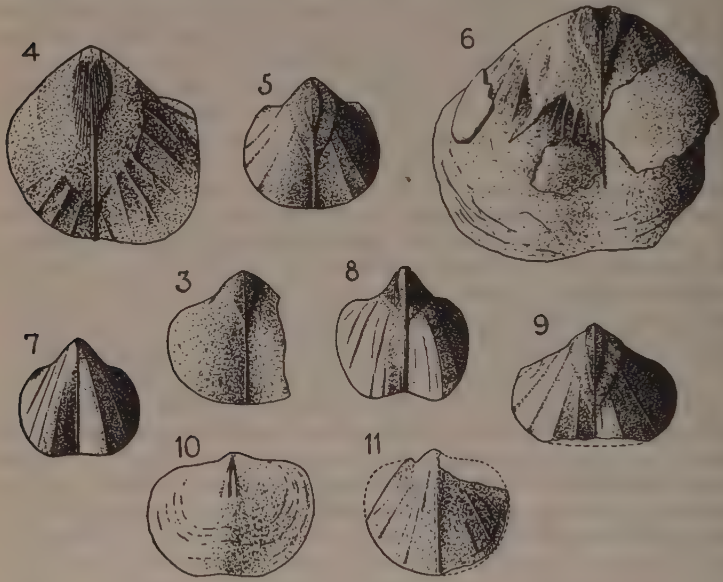
[1] S. S. Buckman, "Brachs. of the Namyau Beds": *Pal. Indica*, 1917, p. 7.

$\frac{1}{5}$ to $\frac{1}{4}$, but in some instances it is much smaller (Fig. 3), whilst in others it may be as much as $\frac{2}{5}$ or even $\frac{2}{3}$ (Fig. 4) the length of the shell. In the great majority of forms the breadth of the area is approximately equal to its length. The scars are divided into well-marked areas corresponding to the impressions left by the adductor and divaricator muscles respectively. No indications of pedicle muscles lying outside the divaricators have been observed.

The adductor scars occupy a more or less narrow elongate linear to trigonal area in the posterior median portion of the valve, and are usually elevated to a considerable extent above the level of the divaricators. The anterior termination is always more or less acute, but the posterior may also be acute (Fig. 5), or rounded, or subrectimarginate (Fig. 4), or rarely possessing a median notch in the posterior border (Fig. 6). In all cases the scar is ornamented with radial striations. It is divided into right and left portions by a median ridge which persists anteriorly beyond the scar to the anterior margin of the shell.



Figs. 3–9.—Casts of the ventral valve of *Martinia* aff. *glabra*; Fig. 4 from Overton, Fig. 6 from Oystermouth, the remainder from Port Eynon Bay.

Figs. 10, 11.—Casts of the dorsal valve of *Martinia* aff. *glabra* from Port Eynon Bay.

All natural size.

The divaricators occupy an area surrounding the adductors, elevated above the level of the flanks and anterior portion of the valve but lower than the adductors. The elevation of both sets of muscle scars above the general level of the valve, and relative to one another, varies considerably. The anterior termination of the scar is usually anterior to that of the adductor, and is much less acute. Laterally the scar may merge into the flanks, or the border, remaining quite distinct, may curve inward and terminate near the umbo. The radial striations which ornament the adductor scar may extend for a short distance on to the divaricator, but frequently they end with the adductor. The divaricators otherwise possess little or no ornamentation other than obscure corrugations and faint continuations of the vascular markings.

In the dorsal valve the muscle area is much less elevated than in the ventral, and little more than faint impressions are usually present. It consists of an elongate triangular area in the umbonal region, extending a distance of about $\frac{1}{5}$ the length of the shell. Frequently the impressions do not admit of subdivision, but in occasional specimens the adductors can be seen surrounded by the divaricators. There is, apparently, not nearly as much variation in the form of the muscle scar as there is in the ventral valve, but occasionally specimens are found in which the impressions are considerably elevated above the surface of the valve.

Genital Markings.—These are represented by a surface scattered with fine points (representing pits in the actual shell substance) and occupy an area around the adductor impressions in the ventral valve. In some forms they completely surround the scar (Fig. 6), but in others they may be present only in the posterior region, or may even be completely unrepresented on the cast.

Vascular Markings.—In the ventral valve these occur as more or less radially arranged ridges, which extend anterior to the muscle scar, and which vary in number, shape, disposition, and length; in rare forms they may be absent (Fig. 7). Generally they are more or less angular and are somewhat irregularly disposed, usually not in a symmetrical pattern. Occasionally they dichotomose (Fig. 4), or more rarely unite. In some forms they continue as faint ridges on the divaricator impressions; in others they merge into the border of the muscle elevation. In the median plane of all forms there is a well-marked ridge which extends from the umbonal region to the anterior margin; sometimes this ridge does not lie in the median plane of the sulcus (Fig. 6).

Vascular markings are usually absent from the dorsal valve, the surface being quite smooth (Fig. 10); occasionally, however, specimens bear faint ridges. These are usually much more even in shape and more symmetrically placed than is usually the case in the ventral valve. They extend from the umbo to the anterior margin (Fig. 11).

Martinia ovaliglabra Vaughan.[1]

This species seems to be intermediate between the ancestral ribbed *Martinia* and *M. glabra*. The pedicle valve is, according to Vaughan, identical with that of *M. glabra*, while the dorsal valve retains traces of a ribbing similar to that seen in *Brachythyris ovalis.* The mesial fold is entire.

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[1] C. A. Matley and A. Vaughan, " The Carboniferous Rocks at Loughshinny ": *Q.J.G.S.*, vol. lxiv, 1908, p. 468.

Martinia multicostata sp. nov. (Fig. 12.)

Two specimens have been found, one, showing both valves nearly complete, being chosen as holotype.

The holotype has a hinge-line straight, short, and a little less than half the width of the shell; beak small, and umbones nearly contiguous; valves in the subintertext stage; margin strongly uniplicate. Dimensions: length, 24 mm.; breadth, 24 mm.; depth, 15 mm.

In the ventral valve the sinus is broad and shallow, divided by a low ridge which is not quite median. This ridge is not seen in the paratype. Surface ornamented by fine growth-lines and a few more prominent growth-halts. On the anterior border there are fine even ribs which become feebler when traced anteriorly, so that they disappear at about $\frac{1}{3}$ of the distance from the anterior margin to the umbo. They are absent from the sulcus and the lateral portions of the flanks, being only seen on the portions of the flanks which immediately border the sulcus. There are about eight on each flank, the whole eight being contained in a length of about 1 cm. along the anterior margin. (In a specimen of *Brachythyris ovalis* in the possession of the writer, at a similar distance from the umbo, there are about 3·5 ribs per cm.)

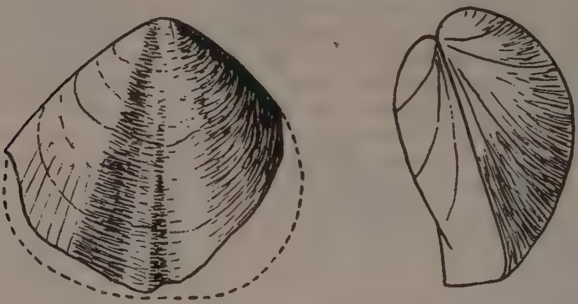

FIG. 12.—*Martinia multicostata* sp. nov. Holotype. Upper Limestone Shales, Oystermouth, Gower. × 2.

The dorsal valve is somewhat crushed, but it appears that no mesial fold is differentiated from a broad mesial swelling. It is ornamented with growth-lines and halts, but no radial ribbing is seen. As is usual in *Martinia*, this valve is somewhat flatter than the ventral.

The holotype is a specimen from the Upper Limestone Shales (D_{2-3} Zone), Oystermouth (Black Lias) Quarry, Oystermouth, Gower. Brit. Mus. (N.H.) Coll., No. B 48911.

The paratype consists of the greater portion of the ventral valve, the dorsal being missing. It differs from the holotype in :—

(1) Its larger size. Length about 26 to 28 mm. ; breadth, about 29 mm.

(2) Its proportions. It is somewhat broader than long.

(3) Its wider and deeper sulcus.

(4) Its more prominent ribs. These extend for a longer distance towards the umbo, and cover nearly the whole of the flanks (about 10 to 12 are present), although being absent from the sulcus.

Horizon and locality as for holotype.

III. General Considerations.

It is probable that apart from the character of their ornamentation, the brachythyrids constitute one of the most primitive groups of spirifers. In the young stage of the shell in most spirifers, as in other brachiopods, the growth-lines curve in towards the umbones, and the hinge-line is only slightly, if at all, elongated. The general trend in most of the genera—*Spirifer* (s. l.), ***Fusella***, *Trigonotreta*—is the increase in length of the hinge-line, possibly associated with close peduncular attachment, and in most species the length of the hinge-line is equal to, or greater than, the width of the shell.

It has been suggested that the elongation of the hinge-line possibly led to the formation of dental plates as a support for the hinge. It may be pointed out, however, in reference to this, that the size of the plates is rarely in proportion to the length of the hinge-line or to the depth of the hinge area. For example, the more common Lower Avonian spirifers, such as *Spirifer striatus*, are very similar in shell-shape and hinge-proportions to the Upper Avonian forms typified by *S. bisulcatus*, but the former species possesses dental plates very much larger than those of the latter. Further, other brachiopods, such as the athyrids, have prominent dental plates but not an elongate hinge-line or a large area. It is possibly significant, however, that the brachythyrids are the only group of spirifers in which the hinge-line is much shorter than the width of the shell, and the only group which at the same time does not possess dental plates.

Nevertheless, while the brachythyrids are presumed to be primitive in the characters of the hinge, their ornamentation has progressed to a much greater degree than is usual in the spirifers. While most forms of the latter are markedly costate, they rarely advance beyond that stage. On the other hand, many, if not all, of the brachythyrid genera pass to what is presumably a catagenetic smooth stage.

The primary smooth stage is unknown, but the first ribbed stages are represented presumably by *Brachythyris linguifera* and *Martinia multicostata* ; they are not known, however, for the group of *Brachythyris integricosta* or for the series of *Martinia ovaliglabra* and *M. glabra*. The costate stage is well represented and includes the typical forms of *Brachythyris*—*B. ovalis*, *B. pinguis*, *B. integricosta*. *Martinia* is only known at this stage by the partially ribbed *M. ovaliglabra*. In the secondary smooth stage there are *Brachythyris sulcata*, *Martinia glabra*, and possibly a smooth form of the *B. integricosta* group, which is at present grouped with *M. glabra*.

The distinctions between the genera are based on the character of the mesial fold. This may be of three types :—

(1) In *Martinia*, the simplest form, the mesial fold is entire, and frequently exists only as a slight undulation, scarcely differentiated from the flanks, on the surface of the valve. This very simple fold persists throughout the changes which occur in the ornamentation.

(2) In the other two forms, the mesial fold is complicated by subdivision, on the one hand, in *Brachythyris pinguis* and similar forms, into an even number of divisions (at present it is never known to possess more than two), and on the other, in *B. integricosta*, into an odd number.

Each of these types of fold seems to have been well-established in the respective genera before the evolution of the ornamentation was well advanced, although in *Brachythyris*, for example, the median groove is frequently much more prominent in the ribbed than in the smooth forms, and the evolutionary stage reached by the ornamentation seems to be quite independent of the degree of complication of the mesial fold, and vice versa. In the catagenetic smooth forms of *Brachythyris* (*B. sulcata*) the median groove is prominent, but no smooth forms of the *B. integricosta* group are known in which a median rib is present on the fold. It may be suggested that a loss of ribbing on the fold as well as on the flanks would give rise to a descendant of *B. integricosta* identical as regards fold and laevigation with *Martinia glabra*—in other words, that *M. glabra* as at present understood may contain the end forms of the *B. integricosta* series. While, theoretically, palaeontologists may be aware of this, it appears to be quite impracticable, on external characters at any rate, to distinguish these homoeomorphs.

NOTE ON THE STRATIGRAPHICAL RELATIONS OF THE UPPER LIMESTONE SHALES OF GOWER.

The succession at the chief localities of the Upper Limestone Shales in Gower may be summarized as follows :—

(1) Oystermouth. Thinly bedded black argillaceous limestones and shales, with cherts. Very fossiliferous throughout. About 200 feet seen (but possibly as much as 350 feet).

(2) Bishopston. Rottenstones, clays and rotten cherts. The beds are steeply dipping and much crushed ; fossils are confined to bands and are also usually crushed. The fauna differs from that of Oystermouth (and of Port Eynon) in the almost complete absence of corals, and in the rarity of spiriferids, particularly of *Spirifer bisulcatus*

(which is replaced by *S. trigonalis*) and of *Martinia glabra*. About 45 feet are seen, but the total thickness of the beds outcropping at Bishopston cannot be much more than about 60 feet. The apparent attenuation in so short a distance from Oystermouth is probably due to a strike fault, and since the fauna differs from that at Oystermouth and Port Eynon, where the bottom beds are seen, presumably the lower portions of the Shales are cut out.

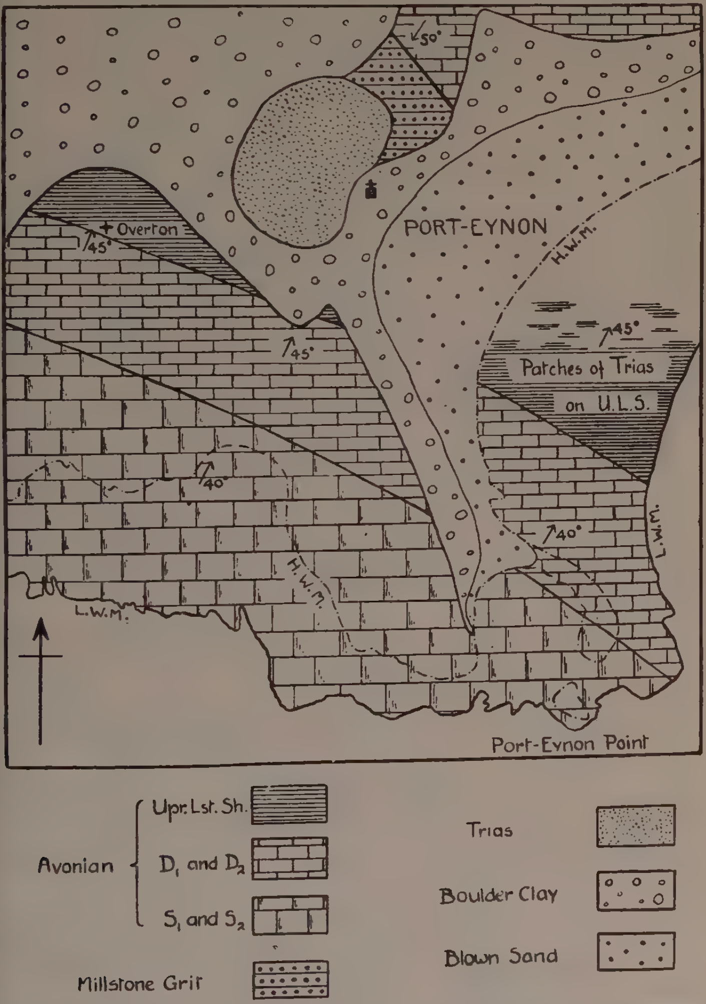

FIG. 13.—Map of the Port Eynon District. Scale: 4 inches = 1 mile.

(3) Port Eynon. (See map.) The shales in Port Eynon Bay

while recognized by the Survey Officers[1] and by Dixon and Vaughan,[2] have received scant attention compared to their representatives in East Gower. Thus Vaughan recorded but three species from there,[3] whereas the fauna is quite as rich as that of the beds at Oystermouth. The lithology, where unweathered, is directly comparable with that of the Oystermouth Black Lias. On weathering, the limestones give rise to rottenstones identical with those seen at Bishopston, while the weathered shales compare closely with the typical Bishopston clays. Beds of limestone are frequently found which are rotten on the outside but possess a solid limestone core. The suggestion that the limestones and shales of Oystermouth are represented at Bishopston by rottenstones and clays is therefore borne out by the evidence at Port Eynon. Rocks showing all stages of decalcification may be found ; the weathered rock does not, however, merge inwards to the hard centre, but there is a very definite boundary between the rotten and the unweathered portions.

About 150 feet of these limestones are seen in Port Eynon Bay. They are usually stained red, owing to a former covering of Trias, patches of which are still seen in places.

The Trias is a conglomerate of rounded and subangular blocks of limestone and Millstone Grit shale, apparently of local origin, in a red calcareous matrix.[4] It is interesting to note in view of the fact that it contains abundant boulders of limestone from the Upper Limestone Shales. Some of these are in the condition of rottenstone, others are only superficially rotten, while yet others are quite unweathered, thus presumably indicating that the formation of rottenstone occurred, to some extent, at any rate, before the close of Keuper times.

At Overton, about $\frac{2}{3}$ mile W. 20° N. of the outcrop of Upper Limestone Shales in Port Eynon Bay, there occurs a wayside exposure of rottenstone with cherts on the lane from Overton to Littlehills. The whole rock is completely decalcified, and presents a similar appearance to that seen at Bishopston. About 15 feet below these rottenstones the massive limestones of D_2 age are seen, so that these beds (the rottenstones) are practically the bottom beds of the Shales. Higher beds are covered by glacial material.

The fossils obtained from Port Eynon Bay (p) and Overton (o) are given in the following list :—

CORALS.

Zaphrentis oystermouthensis Vaughan (p, o). Common.
Z. enniskilleni Edwards and Haime (p).

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[1] "The Geology of the S. Wales Coalfield," pt. ix, "West Gower and the Country around Pembrey" : *Mem. Geol. Surv.*, 1907, p. 14.

[2] Op. cit., p. 551.

[3] Ibid., p. 550.

[4] "West Gower" : op. cit., p. 35.

BRACHIOPODS.

Productus corrugatus M'Coy (p, o).
P. costatus Sowerby (p).
P. longispinus Sowerby (p, o). Common.
P. cf. *margaritaceus* (Phillips) (o).
P. sp. near *semireticulatus* (Martin) (p).
P. sulcatus Sowerby (p, o). Common.
Pustula punctata (Martin) (p, o).
Chonetes spp.
Schellwienella cf. *crenistria* (Phillips) (p).
Spirifer bisulcatus Sowerby and vars. (p, o). Abundant.
S. sp. near *trigonalis* (Martin) (o).
Ambocoelia urei (Fleming) (p).
Spiriferina insculpta (Phillips) (p).
Martinia aff. *glabra* (Martin) (p, o). Abundant.
Athyris globularis (Phillips) (p, o).
Camarophoria cf. *crumena* Davidson non (Martin) (p).
C. sp. probably new (p). The same form has been found at Bishopston.
Camarotoechia aff. *pleurodon* (Phillips) (p, o).

OTHER GROUPS.

Edmondia sp. (p).
? *Myalina* sp. (p, o).
Zygopleura sp. (p).
Griffithides barkei Woodward (p, o).
"*Glauconome*" sp. (p, o).
Fenestella spp. (p, o).
Monticulipora sp. (p, o).

The Structure and Development of *Holocystis* Ed. and Haime.

By T. A. RYDER, B.Sc.

INTRODUCTION.—The internal structures and development of the genus *Holocystis* Ed. and Haime, of which only one species, the type, has been recorded, have not previously been described. It is the purpose of this paper to repair the omission. This Aporose genus is interesting in that it exhibits certain characters normally well developed amongst Rugosa and in possessing four principal septa arranged in a cruciform manner within the calice, instead of having its septa merely arranged on the hexameral plan characteristic of normal Aporosa. I am greatly indebted to Dr. Stanley Smith for the loan of certain specimens, and for much helpful criticism and advice, and to Professor S. H. Reynolds for access to, and use of, material in the geological collections of the University of Bristol.

Holocystis Ed. and Haime, 1850. *Brit. Foss. Corals*, p. lxiv.

Definition.—Compound, astraeiform, Aporose coral in which the corallites are united by dissepimental tissue and confluent septa. Primary secondary and tertiary septa are present and four of the primary cycle, lying approximately at right angles to each other, are more strongly developed than the other two. Tabulae are well developed.

Genotype *Holocystis elegans* (Fitton). (Sole species.)

H. elegans (Fitton) is of particular interest both as regards its stratigraphical position and its morphology. It is one of the few corals found in the Lower Greensand of Britain; it thus occurs in an arenaceous deposit, associated with an essentially molluscan fauna. Morphologically, it bears a superficial resemblance to a Rugose coral and, in fact, Edwards and Haime regarded it as such, and placed it with *Stauria* in the Stauridae, the first family that they described of that sub-order. Those authors defined the Aporosa as having no tabulae and only irregular dissepimental tissue and septa exhibiting a hexameral symmetry; since the mature corallite of *H. elegans* has well-developed tabulae and dissepiments and its calyx suggests the tetrameral arrangement of the septa characteristic of Rugose corals they felt that this classification was justified. A careful investigation of the ontogeny and internal structures of the species has, however, proved that its rightful place is amongst the Aporosa, for in *Holocystis* the septal insertion is on precisely the same plan as in other Aporose corals, and does not follow the more elaborate system that appertains to the Rugosa.

Synonymy of *Holocystis elegans* (Fitton).

1843. *Astrea* (partim, W. H. Fitton, *Geol. Trans.*, s. 2, vol. iv, p. 352.

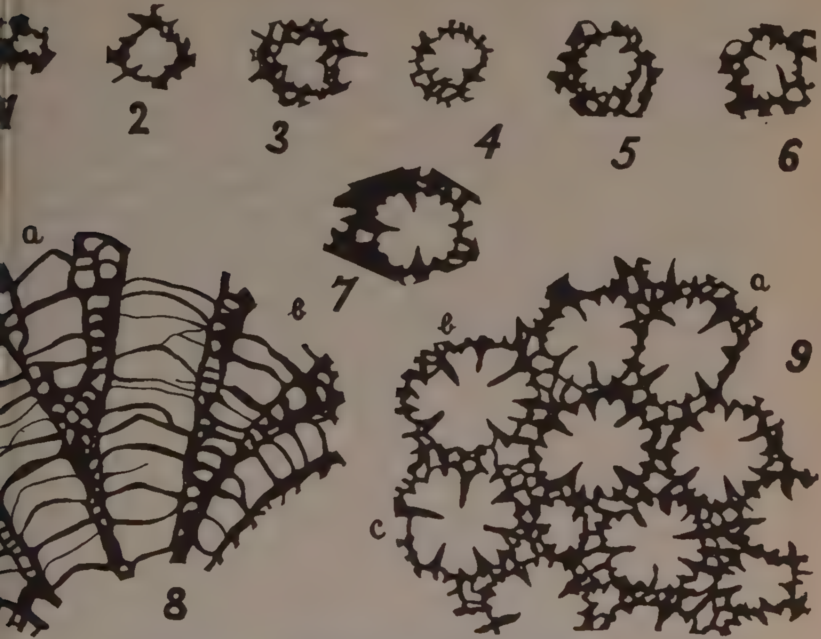
1847. *Astrea elegans* W. H. Fitton, *Q.J.G.S.*, vol. iii, p. 296.

1849. *Cyathopora* (?) *elegans* W. Lonsdale, *Q.J.G.S.*, vol. v, pt. 1; *Proc.*, pp. 83–90, pl. iv, Figs. 12–15.

1850. *Holocystis elegans* H. Milne Edwards and J. Haime, *Brit. Foss. Corals*, p. 70, tab. x, Figs. 5, 5a, 5b.

Fitton gives the name only but Lonsdale describes the specimens collected by him and figures them, although the figures are not good; those given by Edwards and Haime are better, especially Figs. 5 and 5a.

External Characters.—Although the coralla are often very irregular in shape and size, and may attain a width of several inches, the more typical form is that of a hemisphere, 1 inch in height, and 2 or 3 in diameter; they are usually found encrusting a fragment of a lamellibranch shell. The corallites, which radiate outwards in all directions from the point of attachment, display four well-developed primary septa arranged at approximately 90° to each other. The calices are deep, the depth usually being equal to the width, which averages 5 mms., and are separated from each other by a ridge composed of dissepimental tissue.



Figs. 1–9. Sections to Illustrate the Developmental Stages and Internal Structures of *Holocystis elegans* (Fitton).

Fig. 1.—Earliest stage. Six primary septa only are seen.
Fig. 2.—Secondary septa make their appearance, and one of the primary septa has developed more than the others.
Figs. 3–4.—Two primary septa have become enlarged. The secondary cycle of septa is as yet incomplete.
Figs. 5–6.—Three primary septa are now longer and larger than the rest, and the secondary cycle is complete.
Fig. 7.—Three of the four principal primary septa are now developed, and one is developing. Tertiary septa are making their appearance. (Fig. 9*a* illustrates the fully developed corallite.)
Fig. 8.—Longitudinal section, showing mode of reproduction. Note young corallites *a* and *b*, appearing between the older ones.
Fig. 9.—Transverse section of a group of corallites illustrating the internal structures and the way in which the hysterocorallites develop within the dissepimental tissue of mature individuals.

All sections × 5·3 diameters.

Internal Characters (Text-figures 1–9).—The coral is markedly bi-areal both in transverse and longitudinal sections, there being an outer dissepimental zone built up of two or three rows of small, flat dissepiments and an inner tabular area. This latter area is occupied by the broad tabulae, slightly curved distally, which extend across the entire inner area and whose outer edges are bent proximally, thus helping in the formation of the theca which is very distinct in this species. There is no epitheca, the neighbouring corallites being united by their dissepimental tissue as is usual in astraeiform corals.

The form is characterized by the cruciform arrangement of the septa, of which there are usually sixteen present in an adult corallite, representing members of primary, secondary, and tertiary cycles. Four of the primary septa are better developed than the others, and extend almost to the centre of the coral and make angles of approximately 90° with each other. The remaining two primary septa together with two of the secondary cycle attain to about a half or two-thirds this length, whilst the remaining secondary and the tertiary septa are very short, often mere knobs on the thecal wall, although even then they are very unequally developed. The outer ends of the septa of all three cycles penetrate the dissepimental area, and the large primary septum of one corallite is often continuous with a small secondary or tertiary septum of a neighbouring individual.

The columella, which is rarely present,[1] is a solid body and has, in transverse section, the outline of a four-pointed star. A considerable amount of secondary tissue is usually present, especially at the theca and in the dissepimental area.

Reproduction and Development (Text-figure).—Reproduction in this genus occurs by marginal gemmation, the young hysterocorallites developing within the dissepimental tissue common to two or more mature corallites (see Figs. 8 and 9).

The earlier sections obtained (Figs. 1–2) merely show six very short primary septa fringing the thecal ring. Before these develop far, the six secondary septa are inserted. First, one of the primary septa grows larger than the others, then a second, a third and finally a fourth, until the characters of the mature corallite are attained. Before this stage is reached, however, a cycle of tertiary septa, four in number, has been inserted. It is often possible to easily identify the six primary septa in the mature forms, even though there has been a somewhat tetrameral type of symmetry imposed upon the septa.

Localities and Horizon.—*H. elegans* occurs in the Lower Greensand (*Perna*-bed) of Atherfield, Isle of Wight; Peasemarsh, about 5 miles north-west of Rye, Sussex; and at Redhill Cutting, Surrey. The species is also recorded by the Survey from the *Perna*-bed of Sandown and the Ferruginous Sands of Shanklin.

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[1] Edwards' and Haime's figures all show a styliform columella, but very few corallites of the large number examined possessed this structure.

On a Faceted Quartzite Pebble from a Coal-seam at Ashby-de-la-Zouche.

By H. G. Mantle, F.G.S., M.I.Mech.E.

(PLATE VI.)

THE pebble about to be described was found in the Middle Louth Seam at Swannington Colliery, near Ashby-de-la-Zouche, in Leicestershire, and was presented to the writer in the year 1899 by the late Mr. Henry Copson Peake, who at that time was manager of the Swannington Colliery and also general manager of the Walsall Wood Collieries, near Walsall.

Many years previously (1872) Mr. Peake's father, who was manager of the Cannock and Rugely Collieries, found two boulders in the Shallow Coal at the Cannock Wood Pit. One of these was sent to Professor Bonney for examination, and his description of it was communicated to the Cambridge Philosophical Society and published in the Geological Magazine for 1873.[1] Although stray pebbles had been recorded from coal-seams before this date, Professor Bonney was the first to describe petrographically the material of which these erratics are composed. He described the Cannock boulder as a fine-grained quartzite and from his description it would appear that the other erratic was of the same material. A comparison of the Swannington specimen with that of Cannock proves that the latter is a fine-grained grey quartzite identical with that of which the Cannock specimen is composed.

Of later years, many pebbles, mainly of similar or identical material, have been found in the coals of Staffordshire and elsewhere, and these occurrences have been recorded from time to time by Mr. J. T. Stobbs in the *Proceedings* of the North Staffordshire Field Club.

In 1917 Messrs. Lister and Stobbs [2] published a comprehensive paper dealing with all authentic occurrences of pebbles and boulders in the coals of the English and Welsh coalfields, more particularly from North Staffordshire.

They surveyed the literature on the subject up to that date and described an interesting suite of new specimens from the Woodhead Coal of the Cheadle coalfield. They remark that amongst these erratics quartzites predominate and that one or two of the Woodhead specimens exhibit a typical *dreikanter* form. They also discuss the source of the material of which these erratics are composed and, while noting a slight similarity to certain ganisters, they are inclined to regard the material as not having been furnished by any of the Carboniferous sediments of neighbouring or more remote districts. This view was upheld by Dr. Gilligan and is in accordance with that held by the present writer.

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[1] Bonney, *Proc. Camb. Phil. Soc.*, ii (1864–76), p. 301; Geol. Mag. (1873), p. 287.

Note.—A fragment of this boulder was bequeathed by the late Professor Bonney to the Sedgwick Museum, Cambridge.

[2] J. H. Lister and J. T. Stobbs, "Erratics in Coal-seams": *Trans. North Staff. Field Club*, li (1916–17), p. 33. See also *Idem*, lii, pp. 93–5, and vol. liv (1918), pp. 100–1.

Interesting as is the source of the material of which the Swannington pebble is composed, a still more interesting feature is its form (Pl. VI, Figs. 1–2).

It is roughly a slightly depressed triangular pyramid or tetrahedron measuring 2¼ in. in height and 2½ in. in greatest diameter. Its greatest circumferential measurement is slightly over 6 inches. The three upper faces are fairly flat and sharply cut, but slightly hollowed at their centres.[1] They meet in a blunt apex and their edges are rounded. The triangular base is somewhat irregular and shows signs of faceting by three low angled planes, none of which is parallel to any face on the upper surface. Only one of the upper faces appears to have been determined by a structure present in the rock, and this is obviously parallel to à plane of weakness.

On showing the specimen to Dr. H. H. Thomas, he expressed the opinion that the form of the pebble was that of a dreikanter, but that its wind-cut edges had been rounded by subsequent water-action. He thought that the striking form of the pebble together with the circumstances and early date of its discovery made it worthy of record and description.

The most interesting points that arise from a study of the pebbles from coal-seams in Central England and which call for explanation are firstly the general prevalence of a fine-grained grey quartzite as the material of which the pebbles are composed; secondly, the occurrence of these pebbles at many different horizons within the Coal Measures and their wide distribution; and thirdly, the frequency with which these pebbles show faceting and exhibit the dreikanter form.

It is difficult to imagine that this faceting could have been accomplished in any other period than that of the Coal Measures, and if this surmise be correct it would indicate that while humid conditions and a dense vegetation clothed the low ground and coastal flats, higher ground not far distant must have been under arid conditions, more or less devoid of vegetation, and the rocks subjected to wind erosion.

EXPLANATION OF PLATE VI.

Two views of a faceted quartzite pebble from the Middle Louth Seam, Swannington Colliery, near Ashby-de-la-Zouche.

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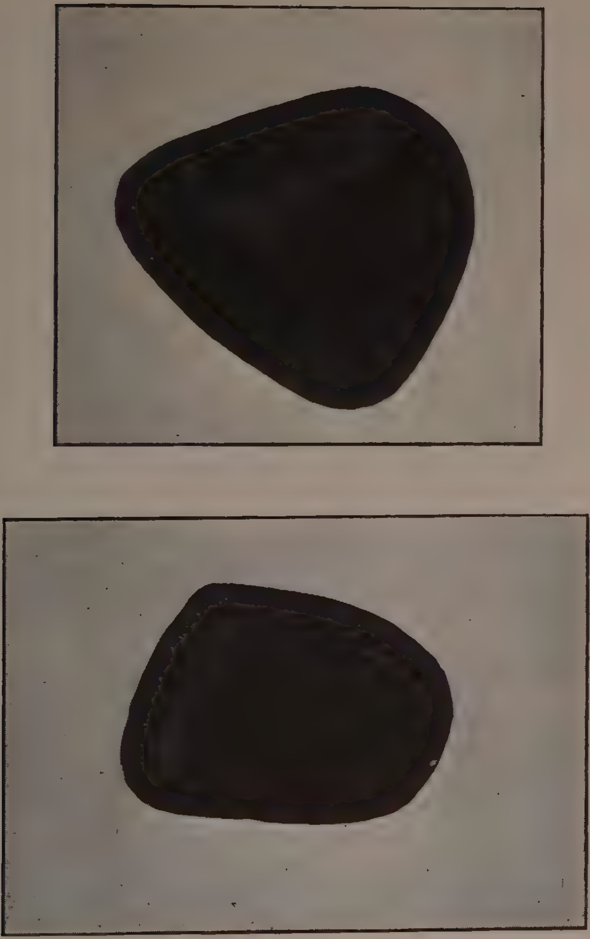
[1] This was a feature noted by Mr. Stobbs in the case of one of the Woodhead boulders (No. 4).



UARTZITE PEBBLE FROM A COAL-SEAM, SWANNINGTON COLLIERY.

[*To face p. 124.*

The Unconformity between the Coal Measures and the Lower Carboniferous Rocks in the Clapton-Clevedon District, Somerset.

By F. Dixey, D.Sc., F.G.S.

IN 1915 I published a short paper[1] in which it was shown that the Coal Measures of the Clapton area on the northern side of the Clifton-Clevedon ridge, Somerset, rested with strong unconformity upon the Carboniferous Limestone and all older rocks. Subsequently Professor S. H. Reynolds,[2] having observed the relations at Court Hill, Clevedon, where the Carboniferous Limestone is clearly thrust over the Coal Measures, saw no reason to differ from the earlier observers, Buckland and Conybeare, the officers of the Geological Survey, and Lloyd Morgan, all of whom regarded the Main Limestone-Coal Measures junction south of Clapton as a faulted one; accordingly, on the map accompanying his paper, Professor Reynolds showed the boundary as a fault as far as the eastern limit of the Coal Measures, even where they transgress from the Main Limestone across the Lower Limestone Shales. At a later date Dr. E. Greenly, in a description of the sections at East Clevedon Gap, about three miles west of Clapton, referred[3] to the unconformity as follows: "Whether, as believed by A. Vaughan and F. Dixey, there be unconformity, the whole of the Visean, with apparently the Lower Coal Measures as well, having been locally removed by inter-Carboniferous erosion, is a question that will not be discussed in this paper. But, independently of that question, there is reason to suspect that the base is cut out, for the lowest visible sandstones on the wooded bluffs are buckling over, as if driven forward on a thrust-plane. Should serious unconformity be eventually proved, this thrust need not be of much tectonic importance. In any case, the plane, whatever its nature, is overstepped by the Bella-Vista Thrust-plane . . ."

The object of this note is to state that Professor Reynolds has recently been kind enough to accompany me over the Clapton area and to consider it in the light of the later work at Clevedon, with the result that he is now able to confirm my view as to the existence of the unconformity; furthermore, we could obtain no evidence in favour of the interpretation that the Coal Measures at Clapton had been thrust over the Carboniferous Limestone or *vice versa*. Fortunately, I have been able to discuss the question with Dr. Greenly also, who has since written me as follows: "In writing of the tectonics of Clevedon, I was careful (*Q.J.G.S.*, 1924, p. 460) to exclude from that paper the question of unconformity between Coal Measures and Limestone Series. The Clapton-in-gordano sections I have never seen; I was but a sojourner in Clevedon, and with my hands full in North Wales, do not intend to do any more work in Somerset."

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[1] "The Relation of the Coal-Measures to the Lower Carboniferous Rocks in the Clapton-Clevedon District, Somerset," Geol. Mag., 1915, pp. 312–16.

[2] "The Carboniferous Limestone Series of the Area between Clifton and Clevedon," *Proc. Bristol Nat. Soc.*, 4th Ser., vol. iv, p. 187.

[3] S. H. Reynolds and E. Greenly, "The Geological Structure of the Clevedon-Portishead Area (Somerset)," *Q.J.G.S.*, vol. lxxx, 1924, p. 460.

I would like to add in amplification of my earlier account that the section at St. Michael's Church, Clapton, shows that the lowest beds of the Coal Measures are not only highly calcareous, but also that they contain pebbles of the underlying limestone. Moreover, the six "islands" of Carboniferous Limestone are seen from my sketch-map to constitute a fairly compact group that extends in a north-easterly direction across the strike of the Old Red Sandstone lying about a mile to the east, and I would suggest that this disposition of the "islands" is most easily accounted for on the following hypothesis. Prior to the deposition of the Coal Measures a strip of Carboniferous Limestone was thrown forward of the main outcrop by an oblique S.W.—N.E. fault that lay several hundred yards east of the site of St. Michael's Church (see Fig. 1); this ridge was then subjected to intense erosion, in the course of which it was cut up into the group of small isolated masses which we now see, and afterwards these masses became completely overlain by the accumulations of Coal Measure times. This would account also for the considerable depth of the Coal Measures, as observed in several small shafts, within a very short distance of the limestone outcrop; a good example of this may be seen at the shaft lying nearly 300 yards S.S.E. of St. Michael's Church. Subsequently to the deposition of the

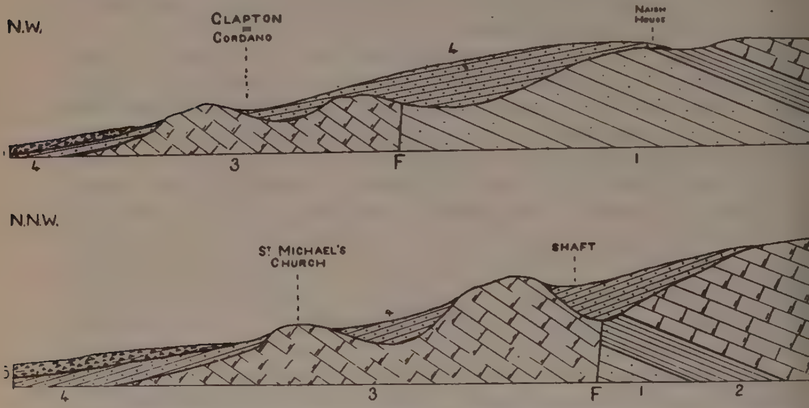

FIG. 1.—Rough Sections across Clapton Coalfield, Somerset (F. D.). Length of Section: Lower, 1½ miles; Upper, 1 mile. Vertical scale three times the horizontal. 5. Trias. 4. Coal Measures. 3. Main Limestone. 2. Lower Limestone Shales. 1. Old Red Sandstone.

Coal Measures the area has been tilted to the north or north-west, so that the southern limestone outcrops now lie more than 200 feet above those to the north, and, further east, the base of the Coal Measures first steps across a little valley in the Lower Limestone Shales and then runs down the slope of the hill across the upper beds of the Old Red Sandstone on to the lower conglomerates. This overstep has every appearance of being due to ordinary unconformability, and there is no evidence to suggest that it may have been complicated by thrusting; nevertheless, this unconformable relation is certainly obscured by thrusting several miles further west along this boundary.

In the Nailesa area south of Clapton on the other side of the Clifton-Clevedon ridge, the Coal Measures step across on to the *Seminula*-beds of the Carboniferous Limestone[1]; and in all probability this relation is also essentially due to unconformability.

In my original paper on Clapton area I stated: "It is evident that in Carboniferous times the district suffered not only considerable folding, but also much faulting, as shown by the relative position of the islands and main outcrop of Carboniferous Limestone. Unconformity between the Coal Measures and the Lower Carboniferous has recently been demonstrated in the Titterstone Clee Hills by Mr. E. E. L. Dixon,[2] and in the Forest of Dean coalfield by Professor T. Franklin Sibly."[3] I might add that at a later date it has been shown also that the Millstone Grit of the eastern part of the South Wales Coalfield rests unconformably upon the Carboniferous Limestone.[4]

Accordingly, in view of the known extent of this intra-Carboniferous disturbance and of its magnitude in the Clapton area, it is difficult to avoid the conclusion that it exists also at Clevedon at a distance of only 3 miles to the west, and that the break there observed between the Coal Measures and the Carboniferous Limestone (apart from certain demonstrable thrusts) is due essentially to the presence of this unconformity.

Modern Pools and Carboniferous Analogies.

By Benjamin Millard Griffiths, D.Sc., F.L.S.

THE origin of coal is a difficult problem which is very far from being solved. The Coal Measure flora has long been extinct, and the modern representatives are feeble folk, almost crowded out of existence by plants of very different appearance and internal structure. The modern marsh flora is not primitive but secondary, and consists almost entirely of land plants which have taken to the water habitat again, just as the whale, porpoise, and seal are land animals which have gone back to rejoin their remote ancestral relatives in the sea. Homologous comparisons between past and present are therefore practically impossible, but some common pool developments of to-day may provide useful analogies if nothing more.

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[1] See S. H. Reynolds, *Proc. Bristol Nat. Soc.*, 4th Ser., vol. iv, p. 187.

[2] Geol. Mag., 1910, p. 458.

[3] Geol. Mag., 1912, p. 420.

[4] See F. Dixey and T. F. Sibly, *Q.J.G.S.*, vol. lxxiii (1918), p. 111, and E. E. L. Dixon, ibid., p. 161.

The interbedded sandstones, shales, and clays of the coal seams would apparently indicate areas where the lake banks or river banks were of relatively soft rock, which provided much detrital matter. Our modern instances, therefore, will not be taken from pools and lakes of the Cumbrian type (see Pearsall, 9[1]), or the Highland type (West and West, 11 ; Murray and Pullar, 7), where the steep banks are often of crystalline or indurated rock, and the sediments and marsh fringe are scanty in amount. Our examples will be chosen from the lowland waters of England where the more friable Triassic and later strata allow the formation of shallow, rounded basins, fringed with extensive marsh. Natural lowland waters are relatively rare, because lowland land is valuable and shallow basins are easy to drain, but some still exist in Shropshire, Cheshire, Yorkshire, Norfolk and other counties (Griffiths, 3). Artificial pools show much the same features but the shape is usually that of an isosceles triangle and the deepest point is at the basal end next the dam, instead of in the centre. In these lowland pools, there can be distinguished the following zones of vegetation making up the marsh : (*a*) the reed fringe with its conspicuous vegetation of Reed (*Arundo phragmites*), Lake Rush (*Scirpus lacustris*), Bull Rush (*Typha* spp.), Burr Reed (*Sparganium* spp.), and many smaller plants ; (*b*) the fringe of floating-leaved plants, among which are the Water Lilies and the Floating-leaved Pondweed ; and finally (*c*) the zone of submerged plants, comprising Pondweeds of various kinds. Beyond the marsh lies the area of open water in which live the microscopic free-floating plants making up the phytoplankton.

The plants of the marsh-fringe all have their roots embedded in a richly organic mud or ooze, which is formed from the decay of their dead parts. The finer fragments of the organic remains are easily disturbed by ripples and currents, and this organic ooze drifts out far from the point of origin and settles down over the bottom of the pool, as a layer of very fine sediment, which may be over 90 per cent organic matter (see Pearsall, 9, p. 195, and Rankin, 10, p. 258). The character of the organic sediment varies to some extent with the type of vegetation. The Reed and the Lake Rush have tough skins and a fair amount of fibre. In Stanklin Pool, Worcs., where these plants predominate in the marsh, the sediment is greyish and flocculent (Griffiths, 4). The Burr Reed, Iris, Bull Rush and the submerged plants in general are more tender and succulent. In Ryton Pool, Co. Durham, where these abound, the sediment is a finely divided black ooze (Griffiths and Cooke, 5). Boggy pools, where *Sphagnum* moss is prevalent, have a brownish-black ooze of fine texture. In Stanklin Pool and in many other pools, the oozy sediment abounds with the freshwater mussel, *Anodonta*.

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[1] See list at end of paper.

The extent of the marsh fringe is determined by the depth of the water, because the roots and lower parts of the plants of the reed-fringe will only endure submersion to depths varying from a few inches to a couple of feet or so, and the floating-leaved plants cannot stand more than about 6 feet. The wholly submerged plants cannot invade far, because all green plants depend upon light, and are therefore stopped at the limit of light penetration. In rocky lakes with little sediment, the water is relatively clear, and the light limit may be about 30 feet (Pearsall, 9), but in lakes of our type the limit may be as little as 6 feet, as in Ryton Pool, because the wind keeps disturbing the fine organic sediment at the shore and drifting it out into the open water. The turbidity of the water cuts out the light very effectively, just as does the atmospheric turbidity of smoke or fog. Beyond the light limit, therefore, there is nothing on the bottom but fine organic sediment or ooze.[1] If the water is deep, the oxygen supply at the bottom is much poorer than nearer the surface or in the shallows. (For gas content of waters see Birge and Juday, 1; also Whipple, 12.)

Occasionally storms may tear off the leaves of the marsh plants and violently disturb the coarse plant remains near the shore. Fragments of stems and seed and fruits may be swept by wind and wave into the bays of the marsh, and are there covered up in patches by sandy sediments. Leaves and twigs might be drifted out into open water and there sink down to form a layer of recognizable plant remains on the black ooze, but for the most part the latter is usually too far from the edge of the pool to receive extensive deposits of fragments of any size. The black ooze of the deep water also lies too deep for wave action to disturb it, and it accumulates quietly and steadily year by year. The low oxygen content of the deep layers of water helps to preserve the sediment from complete dissolution, and in time the amount of this material may be very considerable. For instance, in Ryton Pool, which is less than an acre in area, and scarcely 6 feet deep, the black ooze is at least 3 feet deep in the centre.

The amount of marsh fringe depends on the depth of the water, and if the depth is decreased by any means, either by the lowering of the water level by deepening of the outflow channels, or by the filling up of the basin with sediments, the marsh fringe will advance with the shallowing water, and may finally cover the whole of the pool area with a kind of marsh-forest of reeds and rushes, mixed probably with fen-loving trees like the alder and the willow.

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[1] Perhaps "attritus" is a better term. See Seyler, C. A., in *Nature*, vol. cxvii, 3rd April, 1926, p. 486.

It may happen that the channel of the outflow stream suddenly becomes choked up, by the caving in of its banks. In this case, the pool would re-form again, and the marsh-forest would be drowned out. The trees and reeds would perish and leave only their stumps and roots lying embedded in the old marsh soil which had formed during the forest phase. On the edge of the pool there forms a new fringe of marsh. Once more the decaying leaves among the stems of the marsh plants yield fine organic debris, which is drifted out into the open water and slowly sinks down into the darkness, stillness, and airlessness of the depths. Another layer of black organic ooze is formed, and the old marsh floor with the roots and stumps of the former marsh vegetation still embedded in it, is covered up and hidden by the new deposit.

To give an actual instance, Capheaton Lake, Northumberland, was drained just before the war, in order to kill off the pike which preyed upon the stock of trout in the lake. War came, and the pool was left empty for some years. Marsh vegetation, including willows, invaded the bottom and formed a new land surface on the organic ooze. At the time of the writer's examination of the pool, the water had been allowed to flow in again, and only the tips of a few dead willow branches projecting above the surface of the water showed that the bottom was an old land surface which was being covered again with fine organic ooze.

The Cranberry Bog Plantation at Beamish, Co. Durham, is a wood of silver birch with an undergrowth of bracken fern, and there is no sign of either bog or cranberry until one goes to the far side of the wood where the peat deposit is being worked out by the owner. Here one sees that the top soil is about 4 inches deep, and overlies a 5 ft. stratum of very dark brown peaty sediment. The layer is lighter in colour above, and consists of recognizable fragments of *Sphagnum* moss, containing seeds of the Bogbean. In the lower part of the stratum, the fragments are so small and disintegrated that they form only a dark brown ooze. Beneath the layer of *Sphagnum* peat is a 2 in. band, black in colour, which consists of tightly packed leaves of marsh plants, together with seeds of Bogbean and wing cases of the well-known marsh beetle, *Donacia*. Under this layer lies a 3 in. bank of dark oozy marsh deposit, which lies directly on the sandy clay of the bottom of the basin. The history is plain. Originally there was a shallow pool with the usual marsh vegetation and usual black oozy deposit of vegetable debris. The outflow channel became so choked that the pool began to stagnate, and bog conditions supervened for a long period, during which the *Sphagnum* peat was laid down, and cranberries grew on the surface of the moss. Then men began to mine for coal, and owing to subsidence, the bottom of the basin cracked and the bog was drained. The crack is still visible on that part of the basin floor from which the peat has been removed recently. The moss and the cranberry plants dried and perished, birch and bracken covered the surface as we see it to-day, and only the old name remains to indicate its former state. If further subsidence should close the crack, and if surface drainage should be re-established, a pool would form again, and the present land surface with its trees in situ, would become covered up with a layer of the black oozy debris similar to that which underlies the whole present deposit. Successions of this type are commonly observed (see Rankin, W. M., 10, p. 256; Lewis and Moss, 6, p. 269; Erdtman, 2).

The Carboniferous period was one of great duration. Denudation produced vast peneplains through which wandered great rivers fringed with marshes and lagoons. The conditions were perhaps faintly like the Norfolk Broads but on a gigantic scale (for geography of the Broads see Pallis, 8, p. 219). Arguing by analogy—a notoriously unsafe method, but perhaps justified in this case by the uniformitarian theory—we can imagine a great Carboniferous lake or river lagoon, fringed by a marsh flora of Lepidodendroids, Calamites, and other seedless plants which produce vast clouds of wind-blown spores. On the landward edge of the marsh there are fernlike trees which bear primitive seeds, let us say *Trigonocarpon*, which are shed in due season. These seed-bearing trees are perhaps beginning to adapt themselves to existence on dry land, but like the modern alder and willow, though for different reasons, they still keep to the watery soil. Beneath the open water of the lagoon lies layer upon layer of deep black ooze, derived continually from the decaying debris of the marsh vegetation. The ooze abounds in spores from the marsh plants, because the spores are easily blown by the wind or drifted out by the water, and the sporecoats also resist decay. Storms may tear off leaves and seeds from the marsh vegetation, and waves may churn up the lagoon banks and send layers of sand and silt among the plants of the shore, but only the finest and lightest particles of sediment can reach the open water, and it will be relatively rarely that any leaves or seeds are carried far enough to be deposited on the black ooze in the depths of the water. The coarse vegetable fragments stay near the shore, and are covered up by sand and mud. In the shallow water *Carbonicola* swarms, but the shell fish do not occur in the black ooze of the deep water because they need much oxygen to breathe, and the deep water is poor in that gas.

It happens that the area begins to subside and the new gradients rouse the rivers to great activity, and vast quantities of sand and silt are eroded from the river banks and carried down into the lagoon. The deposit of black ooze is soon buried deep under layers of sand and clay, and the basin of the lagoon is filled to such an extent that the water becomes quite shallow. As soon as shallowing begins, the marsh vegetation can advance, and by the time the system settles down again, the site of the lagoon is covered with a dense forest of marsh plants, and a marsh soil is formed, full of the bases and roots of Lepidodendroids, etc. The marsh humus does not accumulate greatly because oxygen is plentiful, decay is more complete, and frequent rain carries much of the finer decayed detritus into the river which flows through the marsh.

The marsh-forest phase is ended by further subsidence of the area, due either to earth movement or possibly to the great weight of the sands and clays deposited on top of the original black ooze. The marsh-forest sinks with the sagging strata, a new basin is formed, and the vegetation is drowned out and perishes under the accumulating water. The lagoon is formed once more, a new marsh fringe rapidly springs up on the shallow edge of the water, and once again the fine organic debris from among the stems of the marsh vegetation, begins to drift out into the open water. It falls as a steady rain of fine oozy particles, and buries under a new layer of black ooze, the old marsh floor with its tree-stumps and roots still in situ.

On this view, the coal seams are derived from the black ooze deposited in the depths of the lagoon. The sandstones and shales are flood deposits following subsidence, and the fossil tree-stumps in situ with fire clay, are indications of the invasion of the basin of the lagoon by marsh vegetation when the flood deposits had made the lagoon sufficiently shallow for that purpose. Further subsidence repeats the cycle.

The brown coals or lignites are probably derived from peat deposits, in a manner similar to that described for the Beamish deposits, except that the causative factors are earth movements and not cracks due to mining subsidence.

The controversy among geologists about the deposition of coal circles round the "in situ" theory and the "lagoon deposit" theory, but if the above explanation is correct, the theories are simply two aspects of the same thing. The black ooze actually originates in situ among the bases of the marsh vegetation, because it is simply the finest of the debris formed from the decay of leaves and stems which have fallen on the floor of the marsh. It does not stop there, however, because owing to its fineness and lightness, it is drifted by waves and ripples over the whole surface of the lagoon, together with the innumerable spores from the living marsh trees of the margin. Wind action extends only to some 25 feet even in exposed lakes, but when the lake edge is fringed by marsh, the vegetation acts as a wind-break and the depth to which disturbance reaches is much less, e.g. Ryton Pool. The calm, deep area available for deposition is therefore usually ample. The "in situ" material, therefore, is being constantly drained of its finer constituents to form "a lagoon deposit" in the depths of the basin. The fine debris which falls near the shore is churned up with the sand and mud of that region, where it doubtless helps to feed *Carbonicola*, and later on, mixed with *Trigonocarpon* seeds and partly decayed leaves and stems, it assists in forming the fossiliferous shales and sandstones.

My colleague, Dr. Arthur Holmes, head of the Department of

Geology at Durham, has suggested that the ideas put forward above, particularly that of the invasion of the marsh flora, and the subsequent submergence of the latter, may be of interest to geologists. It must, however, be clearly understood that these views are derived analogically from modern studies in ecological botany, and their validity depends entirely on stratigraphical confirmation.

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REVIEWS.

DIE GASTROPODEN DES BALTISCHEN UNTERSILURS. Von ERNST KOKEN. Fortgesetzt von Jar. Perner. pp. vii + 326, 41 tafeln, 44 textfiguren. Mémoires de l'Académie des Sciences de Russie, Ser. viii, Tom. xxxvii, No. 1. Leningrad, 1925.

THIS volume contains a valuable addition to our knowledge of the early Palaeozoic Gastropoda. Professor E. Koken had made studies for it during eighteen years, but his work was cut short by death in 1912, after which Dr. J. Perner completed it; publication, however, was delayed by the Great War and the unsettled state of Russia. The first 200 pages were printed in Koken's lifetime during the years 1902–7, therefore it was only in the later part that Dr. Perner could make alterations, and add six plates, and phylogenetic tables.

There are described and figured a total of some 369 species and varieties, which are referred to seventy-six genera and eighteen families. About three-quarters of the species are attributable to Koken, some were described in his previous works, but comparatively few were figured.

In the first part there are given eight families, the *Bellerophontidae*, *Raphistomidae*, *Euomphalidae*, *Euomphalopteridae*, *Macluriidae*, *Pleurotomariidae*, *Polytropidae*, and the *Trochonematidae*. In the later part there are ten families, the *Turbinidae*, *Umboniidae*, *Cyclonematidae*, *Capulidae*, *Clisospiridae*, *Onychochilidae*, *Murchisoniidae*, *Loxonematidae*, *Subulitidae*, and the *Patellidae*.

Among the phylogenetic tables given, the most complete are those of the *Raphistomidae*, *Euomphalidae*, and *Pleurotomariidae*, which families are considered closely related, and to have been derived from the same stock. The first-named is shown to have the earliest representative, and the shortest range, appearing in B_2a, continuing to F_1, and having only one species in the upper strata (Silurian). Members of the *Euomphalidae* occur in B_2b, and of the *Pleurotomariidae* in B_3a, and their descendants continue onwards to the Jurassic. There are also tables of the *Murchisoniidae* and *Loxonematidae*, which are regarded as closely connected, and to have appeared almost simultaneously in E_1–F_2 of the Baltic region, as well as in the Trenton and Black-river Group of North America.

The plates and text-figures demonstrate the character of the fossils well; the descriptions are adequate, but the absence of clearly stated dimensions in the latter is to be regretted, especially as the degree of magnification is not always indicated in the explanation of the plates.

J. L.

THE BEMBRIDGE FLORA. Catalogue of Cainozoic Plants in the Department of Geology, British Museum. Vol. I. By ELEANOR M. REID and MARJORIE J. CHANDLER. With a section on the Charophyta by JAMES GROVES. London, 1926. Price 15*s*.

SINCE the publication by the Palaeontographical Society, about forty years ago, of Mr. Starkie Gardner's Memoir on Tertiary plants, only a very few systematic papers on small collections have appeared ; now, after a long interval, we have an authoritative account of a large flora. The recent acquisition by the British Museum of a very good collection of specimens from the Middle, or possibly Lower, Oligocene Bembridge beds provided the necessary stimulus, and it is fortunate for palaeobotanical science that the description of the material was entrusted to Mrs. Reid and Miss Chandler. The fossils were obtained from the Bembridge series by James E. E. A'Court Smith, who devoted himself, after retiring from the Merchant Service, to the collection of material at Gurnard Bay and Thorness Bay about 2 miles south-west of Cowes. Many of the specimens were found in the Insect limestone above the Bembridge limestone proper. The plant-beds were, it is believed, deposited in a large delta with extensive mud-flats " in an area of depression subject from time to time to changes of level which controlled the invasion and exclusion of the sea ". The plants indicate warm, temperate, and subtropical regions. Fruits and seeds are abundant ; leaves less common, and very few species are represented by both vegetative and reproductive organs.

In a well-written Introduction the authors discuss many interesting questions : the habitats of the plants ; the relation of the Bembridge flora to the Upper Eocene flora of Hordle, the Mio-Pliocene flora of Pont-de-Gail, and the Mid-Pliocene flora of Tegelen, with all of which they are thoroughly familiar. The elements of the four floras are tabulated according to the present geographical distribution of the several genera with which the fossils are compared, and by this method they enable us to follow the history of Tertiary vegetation. Between the Upper Eocene and the end of the Pliocene period a series of changes occurred by which the European flora was transformed from one mainly of East Asian-American affinity to one of European affinity. The genera became more and more European until in Cromerian time the whole flora was Europeanized. There was a southward migration in the northern hemisphere from some circumpolar source from at least as early as the Middle Eocene. It may safely be asserted that a southern migration of Angiosperms began early in the Cretaceous period. The migration during part of the Tertiary period was checked by barriers throughout most of Asia and the whole of Europe ; in the Far East and America the wandering of plants equatorwards was unimpeded. It is significant that the present occurrence of some older Tertiary genera in Africa and India suggests that, in an earlier

Tertiary stage, the barriers formed subsequently by the Alps were not operative.

The authors point out that the amazing wealth of the vegetation of the Far East has been realized only in recent years; we now know that it is mainly in the forests of China we are likely to find existing species most closely related to many Tertiary, European types. To the older palaeobotanists, whose contributions to Tertiary botany have long been standard works of reference, the far eastern floras were practically unknown. It would be a good deed critically to revise their results in the light of the new knowledge.

The descriptions of the specimens are admirably given; clear and concise, and illustrated by well-reproduced photographs. The table facing page 32 should be consulted for the geographical ranges of living species with which the fossils are compared. Mr. James Groves contributes a valuable section of the Charophyta which are represented chiefly by detached oogonia.

The widely distributed species *Acrostichum lanzaeanum*, closely allied to the common *Acrostichum aureum*, is the only Bembridge fern which can be determined with confidence. A new species of *Azolla*, a genus which is now establishing itself again as a member of the British flora, in its reproductive organs is " more closely akin to each of the two living groups " of the genus than they are to each other. Conifers are poorly represented by well-preserved specimens; a species of *Araucarites* is fully described by Dr. Florin of Stockholm. New species of Monocotyledons are described, and a new genus, *Palaeothrinax*, is added to the palms. A new genus of Juglandaceae is appropriately named after the late Mr. R. W. Hooley, to whom the recovery of the Bembridge collection is due. A new species of poppy, *Papaver pictum*, is of special interest as it appears to be a connecting link between the western European flora and the flora of Spain, giving us, as the authors say, a glimpse of a stage in the European history when, before the existence of a transcontinental barrier, Spain received elements from other parts of Europe. Among species founded on leaf-impressions are two assigned to *Cinnamomum*. The determinations may well be correct; but it is stated that the epidermal cells do not show the sinuous walls usually associated with recent species of the genus. In view of the occurrence in several other recent genera of the venation characters very similar to those of *Cinnamomum*, one would like to know if the authors have examined the cuticles of *Viburnum davidii* and *V. cinnamomifolium*, two Chinese species. A useful bibliography is appended; a paper by Engelhardt and Kinkelin on an Upper Pliocene flora of the Main valley (1908) was probably seen by the authors, but it is not included in their list.

It is a pleasure to pay a tribute to the authors and to the Keeper of the Geological Department for the service which they have rendered to science. The work before us is a sufficient answer to botanists and others who assert that the determination on scientific lines of Tertiary plants is an almost hopeless task. The authors do not hesitate to admit that certain specimens cannot be referred on sufficient grounds to a precise position; their results, based on an intensive study of fossil and—what is more important—recent species, inspire confidence and can be accepted as trustworthy data. One may conclude by expressing the hope that this volume will be followed at no distant date by other contributions from these competent investigators to Cainozoic Botany.

A. C. S.

THE PRINCIPLES OF PETROLOGY: AN INTRODUCTION TO THE SCIENCE OF ROCKS. By G. W. TYRRELL. pp. 349; diagrams 78. London: Methuen and Co., 1926. 10*s*. net.

IN this, the first product of a new Geological Series, issued under the general editorship of Professor Gregory, Dr. Tyrrell has provided within the limits of its 336 pages a lucid exposition of the principles of the rapidly growing science of petrology. In turn the igneous, sedimentary, and metamorphic rocks are dealt with, the treatment being respectively proportioned in 158, 79, and 86 pages. In the first section particularly interesting chapters are provided dealing with the composition and constitution of magmas, the distribution of igneous rocks in space and time, and the origin of igneous rocks, while in the second a convenient and modern summary is given of sedimentary processes and the resulting products.

The section on metamorphic rocks has distinctive chapters on cataclastic metamorphism and its products, and on metasomatism and additive processes of metamorphism. A welcome element throughout is the attention devoted to recent petrological work in all its branches. It is here, we may venture to note, that the author has laid himself open to criticism by a somewhat too ready inclination to accept, or, at least, to state without cautionary comment, statements and inferences which are by no means established. We find, for example, the scarcely logical inference of the existence of two *primary* magmas based on a frequency distribution curve for the visible igneous rocks (p. 53). Again, on p. 77, a discontinuous reaction series is presented without a word of caution. It must be confessed that two of the links (Mg and Ca pyroxenes, biotite, and potash felspar) uniting this chain are very shadowy, and the evidence for their real existence would have been welcomed. Surely, too, some critical commentary should accompany the announcement that granite may (or has in Scotland ?) arise by a reciprocal reaction process involving gabbro magma and shaly sediment (p. 166) ? The classification of the metamorphic rocks as given in the tables on pp. 278–80 is so unsatisfactory that it might well have been omitted. Moreover, the terminology is not altogether felicitous.

One shudders to think that a basic igneous rock, however transmuted, should, in our time, ever come to be referred to as "hornblende slate". In the section on the thermally altered rocks (pp. 295, 297), we are told that metamorphism was effected at some temperature between 1000° C.–1400° C., a figure which probably exceeds the real value to an extent measurable in hundreds of degrees.

The author concludes his account with an absorbing section on "anatexis" and "palingenesis", in which "by the regional remelting of metamorphosed rocks in the deeper parts of the earth's crust, the great wheel of petrological change has finally turned full circle" (p. 336). When these drafts upon the imagination have been realized the student would do well to bear in mind the converse dictum that in general "the metamorphic cycle is not closed" (Leith and Mead).

In the foregoing we have dwelt upon matters which touch petrology at its very foundations, and in justice to the student it is well that fact and fancy should be carefully discriminated. In this spirit our comments are now offered.

In all the author has produced an attractive and eminently readable book, expounding the fundamental principles, summarizing the recent advances, and providing in its many references to the literature of the subject the routes to less-explored regions, a book, in fact, which, with these few notes of warning, can be heartily recommended to every serious student of the science.

C. E. T.

Our Early Ancestors. An introductory study of Mesolithic, Neolithic, and Copper Age Cultures in Europe and adjacent Regions. By M. C. Burkitt. pp. xii + 243; 30 text-figures and frontispiece. Cambridge University Press, 1926. Price, 7*s*. 6*d*. net.

THIS work forms an excellent introduction to the study of the Mesolithic, Neolithic, and early Metal ages, and its utility is greatly increased by the Bibliography at the end of each chapter. Although mainly archaeological, some parts, such as that dealing with the history of the Baltic basin, will be of interest to geologists.

Historical Geology, with Special Reference to North America. By W. J. Miller. Second edition. pp. 399; 238 illustrations. London: Chapman and Hall, 1925. Price, 13*s*. 6*d*.

THE author claims in his preface to this edition that more space is devoted to general principles of historical geology and physical history than to palaeontology; nevertheless, the excellence of the palaeontological treatment is the chief recommendation of the book and the figures of the fossils are admirable. The treatment on the stratigraphical side is uneven; the best section is that dealing with the Quaternary; at the other end of the record it seems a pity to retain the much abused term "Huronian" for one of the divisions of the "Proterozoic", as it is sure to cause confusion in the minds of students, and the use of the terms Lower, Middle, and Upper Pre-Cambrian has so much to recommend it. Also, whilst it is no doubt advisable to emphasize the fact that the greater part of the North American Palaeozoic rocks are of shallow water origin, there should surely be some reference to the existence of the great Appalachian and Cordilleran geosynclines, and the facies of deposit characteristic of these. This failure to recognize different facies of deposit, especially in the section dealing with the Palaeozoic, is a serious blemish ; the student, for all the hint there is to the contrary, might expect to find Old Red Sandstone fish associated with Devonian corals ! Otherwise the subject matter is clearly arranged and well illustrated by maps and sections. The book is well got up, and, considering the wealth of illustrations, produced at a very reasonable figure. G. L. E.

THE NATURAL HISTORY OF THE OXFORD DISTRICT. Edited by J. J. WALKER. pp. 336. Oxford University Press, 1926. Price, 10*s.* net.

THIS volume was issued for the meeting of the British Association in 1926. The account of the physiography of the region is by H. O. Beckit ; the geology is mainly by Professor Sollas, with short contributions by K. S. Sandford and W. J. Arkell.

THE IGNEOUS ROCKS OF THE MOUNTSORREL DISTRICT. By E. E. LOWE. pp. 49, map, and 29 figures. The Museum, Leicester, 1926. London Agents : Murby and Co. Price, 6*s.* 6*d.*

THE work of Bonney, Hill, and Watts on the Mount Sorrel area is now extended by the detailed researches set down in this report. The Mount Sorrel granite is here redescribed as " granodiorite ", a name doubtless applied by the author in deference to recent attempts to expunge the term " adamellite " from petrographical nomenclature. A feature of more than local interest is the development at Kinchley of a series of hybrid rocks by interaction of a quartz-mica-diorite and the later " granodiorite ". These interchanges are lucidly described. The photomicrographs accompanying the report seem for the most part well chosen, and are excellently reproduced. C. E. T.

GEOLOGY MANUAL. By R. M. FIELD. pp. vi + 132, with diagrams and two plates of minerals. Princeton : University Press, 1926. London : Humphrey Milford. Price, 18*s.* net.

THIS book is meant for use in the laboratory. For each lesson there are preliminary notes and instructions followed by a space for the student's own work. The aim and scope are indicated by a sentence in the preface. The author asks for criticism " especially from those who have to teach large classes in institutions where an introductory course in Geology is *elected* by the students for *cultural* rather than for *technical* training ". In England somewhat similar practical courses have been developed in the Geographical Departments of some of our Universities and in some Training Colleges. But the book will help them little. The greater part of it is devoted to American topographical maps, and without the special sheets to which it refers it would be useless.

There are lessons on minerals, rocks, geological structure and the study of wind-work, river-action, etc., on topographical maps. In these studies selected sheets are described and others are given to the student to examine for himself. Such work is useful and interesting, but it is not without its dangers, especially to the " cultural " student. He is likely to get the impression that it is safe to deduce the late geological history of a region from the topographical map alone, without reference to the geology or a visit to the region itself.

REPORTS AND PROCEEDINGS.

Glasgow Geological Society.

14*th October*, 1926.

" Some Rare Detrital Minerals in British Sedimentary Rocks and their Significance." By Professor P. G. H. Boswell.

Some special varieties of the more commonly occurring heavy detrital minerals such as purple zircon, chiastolite, deep-red rutile, pseudo-uniaxial mica, and others were illustrated and it was suggested that in certain cases these might be diagnostic of the source of the sedimentary rocks containing them. The characters of other and rarer heavy detrital minerals, including grossularite, pleonaste, cassiterite corundum, sillimanite, chloritoid, glaucophane, monazite, sphene, etc., were described in more detail and their occurrences in British sediments of various ages were noted. Attention was particularly drawn to the relative richness, from the mineralogical standpoint, of certain horizons in the Lower Carboniferous, the Millstone Grit, Permian, Trias, and Lower Cretaceous, the possible sources of some of these " youthful " materials being the subject of discussion. The speaker emphasized the importance of studies of the sediments of the Scottish Lowlands, and of the present-day shore and dune-sands around the Scottish coasts, partly for their own sake and partly on account of the light they would throw on the origin of the sediments farther south.

11*th November*, 1926.

" The Lochs of the Outer Hebrides." By Professor J. W. Gregory, D.Sc., F.R.S.

The archipelago of the Outer Hebrides forms a chain of islands broken up by intersecting systems of sounds and lochs. The W.N.W.–E.S.E. strike of the Lewisian determines the course of some depressions in places where weaker bands have been worn and scooped out by glaciers, but these valleys mostly contain superficial tarns. The major lochs have their orientation at definite angles to the strike, and the directions do not generally coincide with the direction of ice-movement. With exception of the elongated channels of "gutter" type—i.e. with low, gently sloping shores which are probably the remains of pre-glacial consequent valleys—these fiord-channels of the Outer Hebrides recall the "goes" of Caithness and the intersecting systems of tension-clefts, which are characteristic of the West of Scotland and are oriented N.–S., E.–W., N.E.–S.W., and N.W.–S.E. These sets of lines are important in North-west Europe generally. The E.–W. lines are probably to be correlated with lines of weakness and fracture caused by the Alpine disturbances, the oblique lines of the Scottish area resulting from torsion through the subsidence of the North Atlantic. The subsequent widening of the clefts by the Pliocene uplift resulted in the capture of the original drainage, represented by the "gutter" valleys.

EDINBURGH GEOLOGICAL SOCIETY.

11*th November*, 1926.

"The Heavy Minerals in the Torridon Sandstones and Metamorphic Rocks of Scotland, and their Bearing on the Relative Ages of these Rocks." By William Mackie, M.A., M.D., LL.D.

Among the most important of the heavy minerals and at the same time the most durable and the less likely to be modified by metamorphic action are the zircons. It has been found that the zircons of the "Torridons" and the metamorphic rocks with a few local exceptions fall into three great classes which can be traced through all the rocks which come within the field of inquiry. The variation in numbers of these three classes of zircons affords a key not only to a natural classification of these rocks into specific groups, but further indicates in a general way their sequence in time.

The three groups of zircons are: Group A, derived from the Archaean Gneiss; Group B, derived from the foliated granites of the North of Scotland, particularly the Inchbae augengneiss of Central Ross-shire, but including the zircons of other foliated granites as well; and Group C, of uncertain origin, but occurring in immense numbers in the Moine Schists and there familiarly known as the Moine Group of Zircons.

Among the chief results of the investigation are: the conclusion that the "Moines" preceded the "Torridons" in time; that the latter rocks were derived in part from the Archaean rocks and in part from the "Moines"; that the metamorphosis of the "Moines", though broadly contemporaneous with the metamorphosis of the other metamorphic rocks, was a comparatively late feature in their development and followed the period of deepest depression of the sediments which is indicated by the band of limestones running north-east to south-west through the centre of Scotland. The quartzites of the North-West Highlands were largely derived from Archaean rocks, while the quartzites of the north-east and other parts of Scotland were mainly derived from the waste of the "Moines".

"A Dry Valley at Onich, Inverness-shire." By Frederick Walker, B.A., Ph.D.

A good example of a dry valley at Onich (Inverness-shire) was described. Evidence was advanced to show that this ravine was eroded by the River Righ, which was afterwards diverted from its course by a landslip a mile from the sea. This caused the River Righ to take its present precipitous course to Loch Linnhe, and left the part of the valley below the landslip entirely without surface drainage.

CORRESPONDENCE.

THE CRETACEOUS SHALES OF JAMAICA.

Sir,—At the end of his paper on the Molluscan fauna of the Cretaceous Shales of Jamaica (Geol. Mag., February, p. 64), Dr. Trechmann once more calls me to task for my stratigraphical deductions from the Echinoids of associated deposits. In this case he brings forward over seventy-five Molluscs to overawe me. Out of this number *two* are identified with previously known species—*Neithea quinquecostata* and *N. quadricostata*! Thirty-five answer to the name of "sp.", and quite a small proportion of these are compared with other forms. As far as I can make out, an analysis of his comparisons of new, comparable, and undeterminable species, shows that he finds similarities among *fifteen* Upper Cretaceous forms and *eighteen* ranging from the Middle Cretaceous to the Lower Senonian! It is true that this analysis omits one type proper to the Calcaire grossier!

I fancy some other palaeontologists may be a little disturbed by Dr. Trechmann's contention that *Trigonia* does not count—not because his best specimens look as if they had come from the Chloritic Marl, but because "*Trigoniae* are long-lived forms of little zonal value". Still, that is not my business. Had it been said (in general terms) that "Oysters and Scallops look like long-lived forms of little zonal value" I might have been tempted to agree.

I am afraid that unless Dr. Trechmann can give better evidence than this, my obstinate Echinoids will be maintaining their original claim and retiring from the Turonian into the Cenomanian.

Herbert L. Hawkins.

Dept. of Geology,
University of Reading.
4th February, 1927.

HEAVY MINERAL FREQUENCIES.

Sir,—I have noted with interest the suggestion made by Mr. W. F. Fleet in his valuable paper in the November number of the Geological Magazine (p. 505), for a more accurate representation of heavy mineral frequencies in petrographical work. In the course of recent work on certain sands I have followed similar methods, but have found it necessary to take further precautions in interpreting frequency determinations. Mr. Fleet suggests that the percentage frequencies he gives are "exact representations of mineral frequency". This is, of course, true of the slides examined, but it is not necessarily true of the whole of the heavy mineral residue unless the latter has been carefully sampled or mounted entire.

Mr. Fleet also suggests in his summary and conclusions (p. 513), "that a similar calculation of percentage figures on the minerals of such deposits may assist in indicating more definitely the sources from which they have been derived." A study of simple percentage frequencies will not necessarily lead to accurate results in this direction, for what is desirable is the actual amount of the various minerals *in the rock* and not simply their frequencies in the heavy residue. For this purpose the percentage weight of heavy residues should be given when of weighable proportions. It is a great help also in the interpretation of results if the sizes of minerals are incorporated in the frequency table. A frequency of 20 per cent. for grains of 0·1 mm. has a different meaning from the same frequency for grains of 0·05 mm. This is a great objection to the averaging of percentage frequencies, unless the grade sizes are at least approximately the same. A table such as that given at the bottom of p. 509 would aid interpretation of the results much more if some standard method could be adopted to indicate the average sizes of the minerals alongside the frequency numbers such as dots or squares of fixed sizes representing the grading into small, medium, large, and very large. (Footnote, p. 512.)

Alan Stuart.

University College of Swansea.
11th November, 1926.

AN UNNAMED MINERAL OF THE OLIVINE GROUP.

Sir,—In 1906 J. P. Paul (*T.M.P.M.*, vol. xxv, p. 308), in nvestigating a series of alkaline rocks from Tasmania, described an endialite-nepheline-basalt from Shannon Pier, Shannon District, Tasmania, containing a comparatively large proportion (13·7 per cent) of a new mineral which chemical determinations proved to be high in lime, free from magnesia, and readily attacked by very dilute HCl. This mineral Paul decided was probably Ca_2SiO_4. In the same year Day, Shepherd, and Wright (*Amer. J. Sci.*, vol. xxii, p. 295) described the three crystalline forms of calcium orthosilicate, but until quite recently Paul's discovery has been almost entirely overlooked by petrologists. Not till Bowen in 1922 (*Amer. J. Sci.* (5), vol. iii, p. 30) pointed out the close correspondence between the optical properties of the mineral described by Paul and the artificial β Ca_2SiO_4 was attention prominently drawn to this interesting occurrence.

	Cleavage.	α	γ	2 V	Sign.
β Ca_2SiO_4	parallel to prism axis	1·717	1·735	large	+
Tasmanian mineral .	2 olivine-like	1·718	1·746	64°	+

Paul gave no name to the mineral thus determined, and it is probably for this reason that it escaped notice in later years.

In view of the almost certain correspondence between the mineral and β Ca_2SiO_4, some precise name is clearly wanted for this naturally occurring compound. The terms "Kalkolivin" and "limeolivine" are obviously not unambiguous as they have long since been used by earlier workers (whether justifiably or otherwise) for lime-bearing chrysolites or even monticellite-like olivines. Were it not that "Paulite" is already preoccupied for a rhombic pyroxene, this name might with justice be affixed in honour of the discoverer who has given us so excellent an account of the petrography of the Tertiary alkaline rocks of Tasmania.

It may be permitted to suggest for this mineral the name *Shannonite*, after the district from which it was first recognized and described.

C. E. Tilley.